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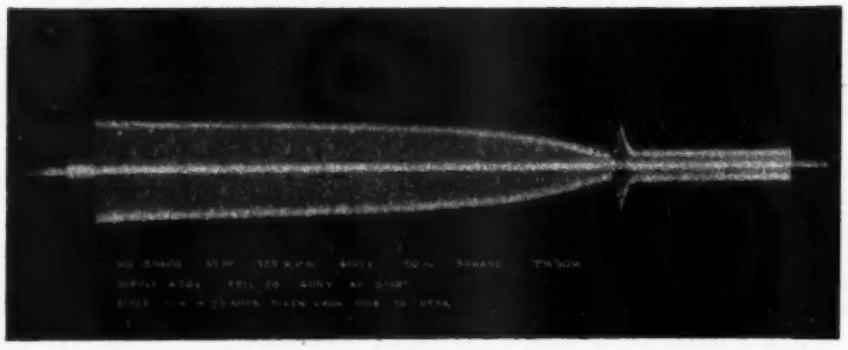

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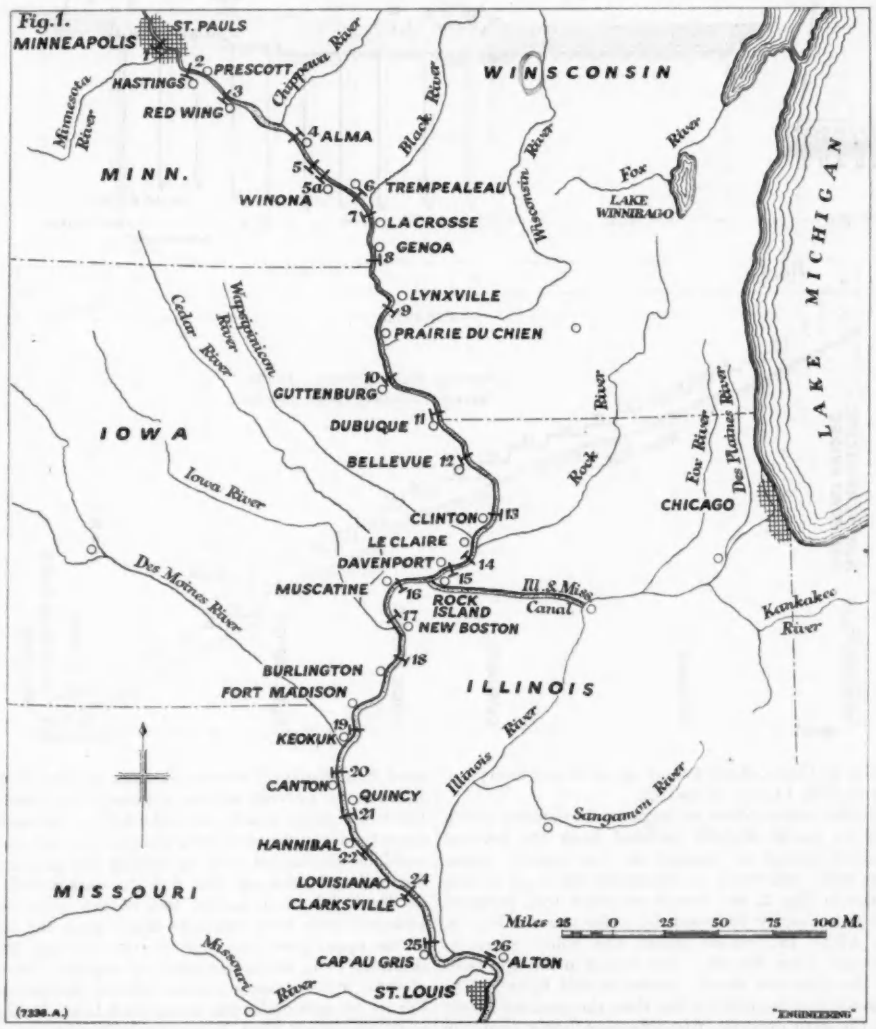
REGULATION OF THE UPPER MISSISSIPPI.

THE Mississippi and Missouri, together, form the longest river system in the world, extending to a length of 4,502 miles. Above its junction with the Missouri, the Mississippi has a length of 1,170 miles and drains an area of 171,500 sq. miles. It rises in the neighbourhood of Lake Itasca, in the north of the State of Minnesota, and some 150 miles to the west of Lake Superior. Combined with the water of the Missouri, it enters the Gulf of Mexico at New Orleans. This article is concerned with that part of the Upper Mississippi lying between the Missouri and the town of Minneapolis, in Minnesota, and having a length of 659 miles. A map of this section of the river is reproduced in Fig. 1, on this page. From the Falls of St. Anthony, situated a few miles north of Minneapolis, the river follows a winding course with many secondary channels and river-side marshes. The banks are low and the riparian country is subject to flooding over areas varying in width from half a mile to five miles. In general, the flood plain is confined within low natural banks. The river slope from the Falls of St. Anthony to the mouth of the Missouri River averages about 0·45 ft. per mile and is fairly uniform except for rapids at Minneapolis; at Le Claire, in Iowa; at Rock Island, Illinois; and at Keokuk, in Iowa. At the Falls of St. Anthony the water surface descends 73 ft. in the distance of a mile. The stream flow is fairly regular and sudden floods of great magnitude are rare.

Fig. 1.



The Mississippi has acted as an important trade artery since the early settlement of the country and local works to improve navigation have been carried out from time to time. These have consisted in the easing of awkward bends and the construction of earthworks to confine the low-water flow to the main channel. In due course, by-pass canals with locks were constructed at the rapids and dredging was undertaken at shallows. In 1907, a project was adopted for the regulation and improvement of the river from the Missouri to Minneapolis, in order to provide a 6-ft. channel throughout at times of minimum flow. The work carried out in connection with this scheme consisted, in the main, of dredging and the construction of wing dams to restrict the width of the low-water channel. As inland transport developed, however, it became evident that a depth of 6 ft. was inadequate for the traffic desiring to utilise the river. At a point 15 miles south of the mouth of the Missouri, the important town of St. Louis is situated, and 180 miles south of this the Mississippi is joined by the Ohio River. Important barge traffic developed on this latter river and utilised the Mississippi up to St. Louis, and conditions showed that trade would be hampered unless such river improvements were undertaken as would permit this traffic to pass up the river as far as Minneapolis.

This state of affairs led the United States Congress, twenty years after the adoption of the 6 ft. project, to direct that a survey of the river between the Missouri River and Minneapolis should be undertaken with a view to the provision of a low-water channel with a depth of 9 ft. As a result of this survey, it was recommended that a channel 9 ft. in depth should be provided between the mouth of the Missouri River and the Northern Pacific Railroad Bridge below the Falls of St. Anthony at Minneapolis. The project involved the construction of a series of locks and dams in conjunction with fairly extensive dredging. The carrying out of the work was authorised by Congress in 1930, various modifications being authorised in 1932. The work was completed last March, at a cost of 170,000,000 dols.

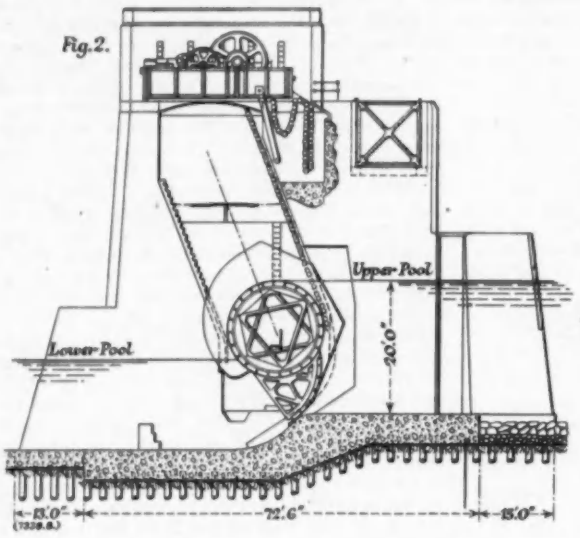
This regulation and canalisation scheme has involved the construction of 25 dams with accompanying navigation locks, the positions of which are shown in the profile of the river which is reproduced in Fig. 4, on page 42. The numbers on this profile correspond with the numbers on the map, Fig. 1. In certain cases, existing works have been utilised. Thus the structures at Minneapolis and Hastings, Dams Nos. 1 and 2, were built, respectively, in 1915 and 1930, for the purpose of improving the navigation facilities. The lift of the locks at Minneapolis is 37·9 ft., as compared with the average of some 9 ft. or 10 ft. The facilities at Keokuk were also previously in existence, having been provided by the Mississippi River Power Company in 1913, when they constructed a hydro-electric plant at the Keokuk Rapids. The lock at this point has a lift of 38·2 ft., which is the maximum for any part of the project. A lock at Le Claire, Dam No. 14, built in 1922 as part of a scheme for passing the local rapids, was also in existence and has been incorporated in the new works. All new locks are 600 ft. long by 110 ft. wide. The old locks at Minneapolis and Hastings are 400 ft. by 56 ft., and the pre-existing lock at Le Claire is 320 ft. by 80 ft.; this latter has, however, been supplemented by a new 600 ft. by 110 ft. lock. The Keokuk lock is 358 ft. by 110 ft., but an additional lock 600 ft. long is to be constructed. At all other places, only one lock has been built, but the layout has been arranged so that a 360 ft. by 110 ft. lock can be added in the future. The absence of No. 23 in Fig. 1 and 4 is explained by the fact that a further dam, originally projected, was eliminated by a modification of the plans.

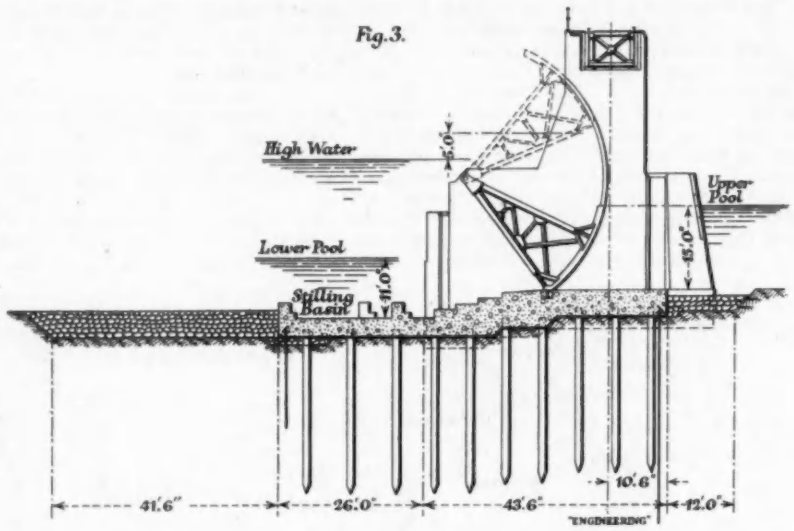
The 25 dams have been designed to maintain a minimum water depth of 9 ft. in the pools above them, at times of low-river flow. In some cases, it has been necessary to dredge the upper part of these pools in order to secure the requisite depth and to remove bars caused by sedimentation. In operation, the water surface in the pools varies from practically level conditions, at times of low flow, to the natural river slope of 0·45 ft. per mile, when more water is coming down. At certain medium rates of discharge, the water levels at the dams may be considerably below normal pool level, since the slope of the pool may be such that adequate depth at points upstream is obtained with the lower elevation of the dam. The employment of this procedure minimises the flooding of adjacent lands. The pools created by the dams are, in general, confined within the natural low banks of the river, but at a few places immediately upstream of some of the dams, overbank areas are submerged to shallow depths. At periods of high discharge, the dam gates are raised well above the water surface and floods pass freely.

The type of dam which has been adopted for this regulation work was determined by the local conditions. Owing to the low banks of the river and the wide and extensively cultivated flood plain, coupled with the fact that many towns and railways have been built close to the banks, it was not possible to contemplate the construction of any type of high dam. It was also very desirable that the type adopted should not in any way impede the passage of flood waters. These considerations led to the decision to utilise movable dams. Some types of movable dam are arranged so that they can be lowered on to the bed of the stream during periods of good river flow, the traffic passing above them and so avoiding the loss of time occasioned by utilising the locks. Conditions on the Upper Mississippi, however, did not permit the adoption of this method of working. The natural depth of water available during the greater part of the navigation season is not sufficient to enable advantage to be taken of the arrangement. As, furthermore, the range of the river between low flow and maximum flood is not great as compared with many other large rivers, it was possible, at reasonable cost, to install gates which could be lifted above high-water level at times of flood, thus opening a free passage for the waters. This type also has the advantage that it permits the free passage of ice, which is an important consideration as the winter conditions are severe. It was finally decided that the most suitable arrangement was a combination of roller gates and Tainter gates.

The dam and lock at La Crosse, Dam No. 7, of which a general view is given in Fig. 5, on Plate

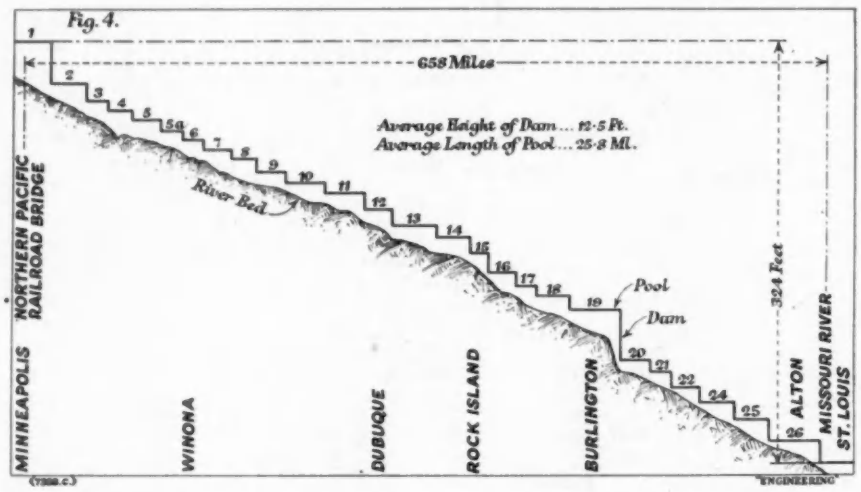
REGULATION OF THE UPPER MISSISSIPPI.





IV, is characteristic of the arrangement generally adopted. The 600-ft. by 110-ft. lock at the river bank can be seen in the foreground, with the upper gates and part of the river wall of the future auxiliary lock alongside. This is followed by the control gate section extending across the full width of the lower water channel. The arrangement in this case consists of five roller gates and eleven Tainter gates. Beyond this there is an earth dam extending to the higher ground on the far side of the flood plain. This embodies a concrete spillway which can be seen in the distance in Fig. 5. The purpose of this is to help to clear heavy floods. In normal circumstances, the roller gates act as a spillway for controlling the depth of water in the pool. The supporting structure for the gates consists of concrete piers which, in most cases, are carried on piles driven into the sand and gravel river bed. Rock foundations could be made at only a few places.

The concrete piers are surmounted by a service bridge along which a locomotive crane can operate for the purpose of placing, or removing, emergency bulkheads or for removing ice and logs which may lodge against the gates. This bridge can be seen in the typical cross section of a roller gate and its supporting structure, which is given in Fig. 2, on this page. Concrete sills, approximately at the level of the river bed, occupy the space between the piers. A concrete apron, with baffle piers and a belt of heavy stone protection, extends downstream to dissipate the energy of the water flowing through the gate openings, and to protect the river bed from scour. Seepage through the porous foundation is checked by a steel sheet-pile dam at the upstream toe of the sill. This is indicated in Fig. 2. A similar diaphragm, but penetrating to a lesser depth at the downstream end of the apron, provides protection against undermining by scour. The arrangement employed at La Crosse is, as already mentioned, characteristic of the majority of the dams. In the cases of Dams Nos. 1 and 19, however, at Minneapolis and Keokuk, comparatively high masonry structures of the overflow type are used. The former is equipped with low crest flashboards and the latter with vertical-lift steel crest gates. Other departures from the normal arrangement are at Hastings, Dam No. 2, where the spillway consists of Tainter gates and a Boule section; and at Red Wing and Rock Island, Dams Nos. 3 and 15, where the flow control sections are made up entirely of roller-type gates. Another exception occurs at Clarksville, Dam No. 24, where all the gates are of the Tainter type. This structure is illustrated in Fig. 6, on Plate IV. This shows the dam when the gates were being lowered for the first time to start the filling of the navigation pool. In Dam No. 25, at Cap au Gris, and illustrated in Fig. 7, the roller gates are situated in the centre, with groups of Tainter gates on each side. The dams for which it has been possible to secure a rock foundation



are at Le Claire, Rock Island, Keokuk and Saverton, Dams Nos. 14, 15, 19 and 22.

Roller gates consist of large steel cylinders which roll on tracks slightly inclined from the vertical and embedded in recesses in the concrete piers. The roller and track are shown in the cross section given in Fig. 2, the details of which will, perhaps, be more easily followed by reference to Fig. 8, on Plate IV, which shows the roller gates at Winona, Dam No. 5A. The tracks in the side faces of the piers are clearly shown in this figure. The diameter of the roller is less than the nominal height of the gate opening, the difference being made up by aprons attached to the drum, as shown in Fig. 2. The ends of the drum carry spur wheels which engage with racks on one side of the track, so that as the drum moves it rotates. It is raised and lowered by means of a chain wrapped round one end, as shown in Fig. 2. This is operated by a winch situated in the house at the top of each pier. The drums are fitted with end shields which make contact with the faces of the piers, so preventing the water from finding a passage round the ends of the drums and through the recesses in the piers.

Roller gates are more expensive than gates of the Tainter type, but, as the cylindrical construction results in great strength, they are particularly suitable for use in situations in which heavy ice formation has to be dealt with. They are, however, relatively cheaper to build than most other types when a gate of considerable length is required. Long gates provide wide openings for the passage of ice, and, owing to the smaller number of piers, offer less obstruction to the water flow. It is for this reason that at Rock Island, Dam No. 15, roller gates are used throughout. At this site the river is confined in a relatively narrow channel, so that it was desirable to provide as free a passage as possible. The roller gates, which were adopted for the earlier dams to be constructed, were designed so that water could be discharged only by raising the gate from the sill and allowing the flow to pass below it. At Rock Island, however, two of the gates were arranged with their summits lower than the level of the upper pool, in order to allow ice and drift, skimmed from the water surface, to pass. Neither of these arrangements proved entirely satisfactory. For ice to pass under the gates, such large openings were necessary that excessive reduction in the level of the pool resulted, and the skimming action of the two gates at Rock Island was found to be insufficient to clear heavy ice. The gates of later construction are designed so that they may be lowered several feet below the normal level of the pool, allowing even heavy ice to pass over the top.

Tainter gates, in their simplest form, consist of a segment of a cylinder carried at each end by radial arms pivoted on supporting piers. The arrangement is illustrated in Fig. 3, above. The first Tainter gates constructed for the Mississippi regulation were of this simple type. They were 35 ft. long and had skin plating only on the upstream face, as shown in Fig. 3. Some gates of this type can be seen in the foreground of Fig. 9, on Plate V, which shows Dam No. 16, at Muscatine. In later designs, the gates are plated all over, so that they may be submerged for passing ice and drift. The later gates of this type of construction were increased in length to 60 ft., and in the case of Dam No. 24, at Clarksville, the last to be constructed, the length was further increased to 80 ft. In view of the wide openings thus afforded, no roller gates have been

REGULATION AND CANALISATION OF THE UPPER MISSISSIPPI RIVER.

(*For Description, see Page* 41).

FIG. 5. GENERAL VIEW OF DAM AT LA CROSSE.

FIG. 6. GENERAL VIEW OF DAM AT CLARKSVILLE.

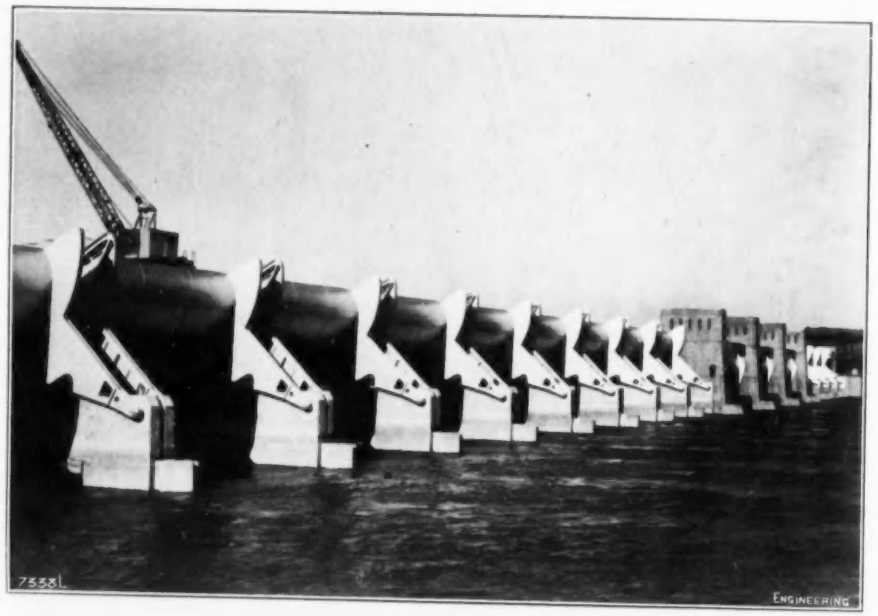


FIG. 7. DOWNSTREAM SIDE OF CAP AU GRIS DAM.

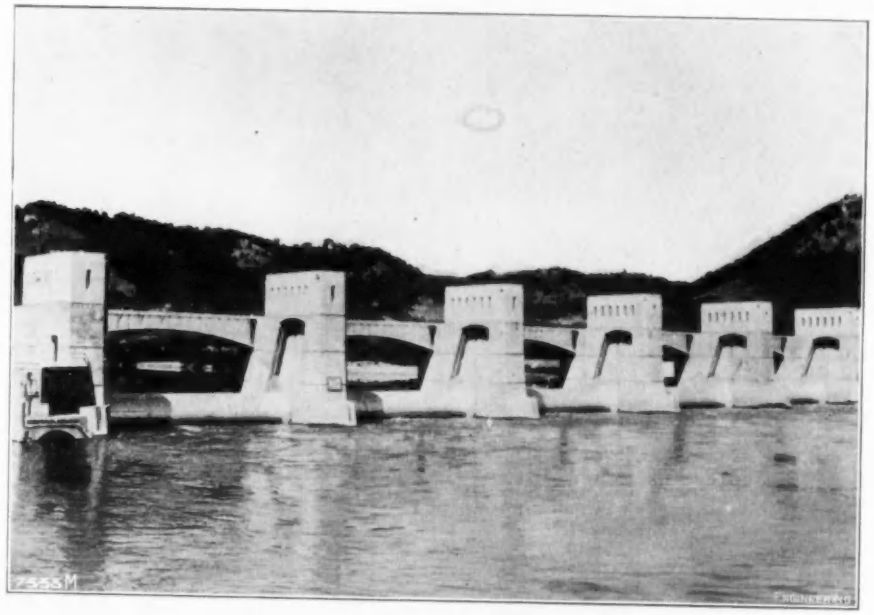


FIG. 8. ROLLER GATES AT WINONA DAM.

(*Between pages* 42 *and* 43.)

REGULATION OF UPPER MISSISSIPPI RIVER.

(*For Description, see Page* 41.)

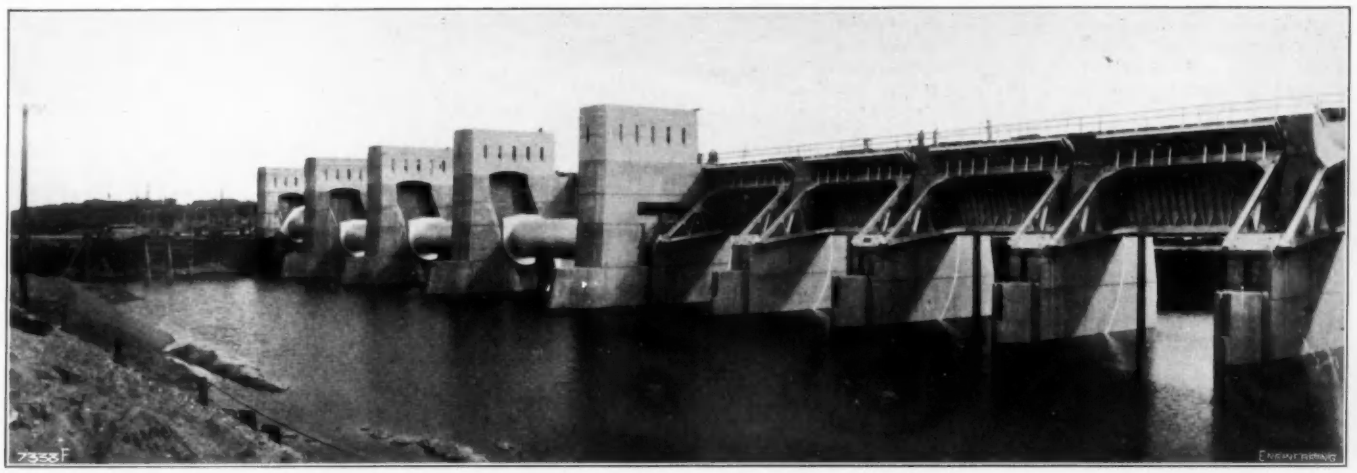


FIG. 9. MUSCATINE DAM DURING CONSTRUCTION.

FIG. 10. TAINTER GATES AT CLARKSVILLE DAM IN OPEN POSITION.

FIG. 11. GENERAL VIEW OF DAM AT ALMA.

(*Between pages* 42 *and* 43.)

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REGULATION OF THE UPPER MISSISSIPPI.

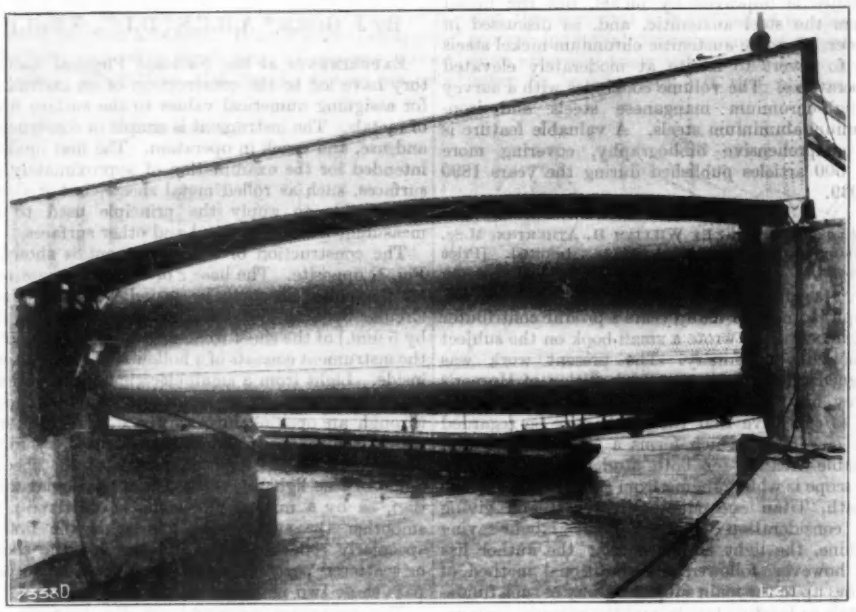

FIG. 12. TAINTER GATE AT CLARKSVILLE IN OPEN POSITION.

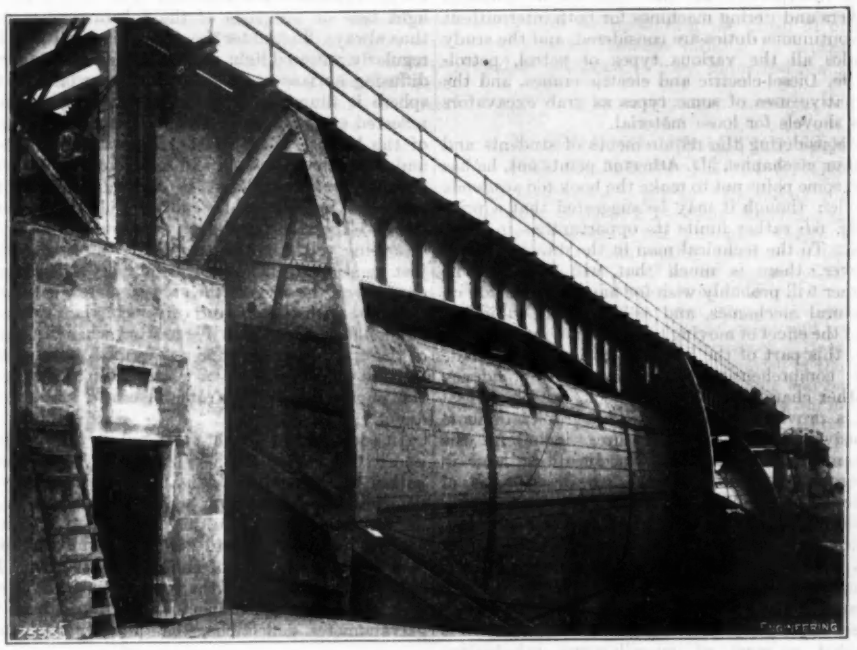

FIG. 13. UPSTREAM SIDE OF TAINTER GATE AT CLARKSVILLE.

provided at the dam, a general view of which is given in Fig. 6, which has already been referred to. The Clarksville gates, some illustrations of which are given in Figs. 10, 12 and 13 on Plate V and on this page, represent a considerable departure from the conventional type of Tainter gate. The structure is in the form of an elliptical tube of considerable inherent strength, so that the internal bracing required is considerably less than is necessary in the normal design. Fig. 10 shows a number of the gates in the raised position, giving wide and clear passages for the river below. A nearer view of one of the individual gates in the same position, but from the opposite side, is given in Fig. 12. The remaining illustration, Fig. 13, shows a gate partly raised.

Two methods of operating the Tainter gates have been adopted. On three of the dams, travelling hoists are used. These move on the service bridge and connection is made with the individual gates as required. This arrangement is in use at Dam No. 4, at Alma, a view of which is given in Fig. 11, on Plate V. The travelling hoist can be seen near the centre of the Tainter gate section. The gates are moved by means of chains connected to them at each end and provided with mechanism to equalise the pull. Locking arrangements enable the gate to be secured in any position. The hoist is connected to the chains of any individual gate as required. On the other dams, which have fewer Tainter gates, and of larger size, independent hoists, situated inside the service bridge, are provided for each gate. One of these hoists can be partly seen in Fig. 13, and the operating chain at each end of the gate can be seen in Fig. 12. The electric motor driving the hoist is situated inside the bridge over the centre line of the gate. The motors are operated by remote control and distant-reading indicators are provided at the switchboard showing the position of the gates. A similar arrangement is used for the control of the roller gates. These latter, and also such of the Tainter gates as are used for the regulation of the pools during the winter months, are equipped with electric heaters. In most cases current is taken from a public supply system, a petrol-engine plant being installed as a stand-by. At Dam No. 2, at Hastings, power is obtained from a water turbine, an emergency petrol set being provided. The same arrangement is used at Rock Island, Dam No. 15, but in this case a public supply is also available, forming a second stand-by. Provision has been made for the future installation of hydro-electric sets at Le Claire and Alton, Dams Nos. 14 and 26.

The general layout of the locks is clearly shown in Figs. 5, 6 and 11. As will be seen, the landward lock walls are extended a considerable distance up and down stream to serve as guide walls for large tows entering or leaving the lock chamber. Haulage equipment is provided to assist the locking operations. Steel mitre gates, pivoted on pintles and gudgeon pins at the lock walls, are used. The closing and opening machinery consists of motor-operated winches connected to the gates by struts. Distant control is used, the switchgear being contained in control cabins on the lock walls at the gates. Limit switches automatically retard the movement and finally stop the gates at the end of their travel. The locks are filled and emptied through culverts extending for the full length of the lock walls and connected to the chamber by a series of ports. Supply to the culverts is controlled by a single remote-controlled valve of the Tainter type at each end. Slots are provided in the upstream wall into which stop-logs may be dropped for unwatering the valve chamber.

The principal traffic on the upper Mississippi River consists of fleets of barges, usually pushed by steamers of the stern-wheel or twin-screw type. The barges range in length from 100 ft. to 300 ft., and in beam from 24 ft. to 48 ft. The capacity varies from 500 tons to 3,000 tons. A "tow" of barges practically filling one of the 110-ft. by 600-ft. locks, carries from 6,000 tons to 8,000 tons of goods, and requires a 1,000-h.p. steamer for its propulsion. Even larger "tows" than this are employed, but are divided when passing through the locks. In operation, it is possible to pass about 50 fleets of barges through the locks in 24 hours. Navigation is not seriously interfered with by bridges. The 52 over-bridges between Minneapolis and the Missouri River in general provide vertical clearances above high water in excess of 50 ft. and horizontal clearances varying from 106 ft. to 710 ft. Bridges with smaller horizontal clearances are generally old and are likely to be eventually replaced. Traffic on the river consists mainly of coal, petrol, fuel oil, steel products and grain. The total tonnage handled between Minneapolis and the Missouri, in 1936, was 2,300,000. About 400,000 tons of this traffic travelled only a short distance on the Upper Mississippi, a large part of the traffic on which consists of short-haul movements of a local nature.

LITERATURE.

Memories of People and Places. By SAM MAVOR. London: William Hodge and Company, Limited. [Price 10s. 6d. net.]

THE reminiscences of engineers are always interesting, but it is not often that they cover so wide a range of scenes and of personalities as does this collection of short essays by Mr. Sam Mavor, the chairman of Messrs. Mavor and Coulson, Limited. As he explains in the preface, they follow no particular plan other than the broad classification into "people" and "places," having been written originally as detached contributions to the firm's *Apprentices' Magazine*. Many, indeed, have no concern with engineering affairs; but among the others are to be found some interesting pen portraits of eminent engineers and their works—for example, Sir John Fowler and Sir William Arrol in connection with the Forth Bridge, Sir Archibald Denny, and the author's brother, the late Mr. Henry Alexander Mavor, who shared with him the distinction of having been associated with Colonel R. E. B. Crompton in the very early days of electric lighting, and who constructed the first electrically-propelled vessel in this country, the 50-ton Electric Arc.

It was difficult, no doubt, to ensure that a miscellaneous assortment of such recollections should be entirely free from inconsistencies, bearing in mind the circumstances in which they were written; but there is at least one direct conflict, in the statements, on page 239, that the Japanese cruiser Takachiho (in which the author served as a junior engineer in 1886) was sunk by the gunfire of a German cruiser, and, on page 240, that she was sunk by the guns of the German forts at Kiauchiau. According to H. W. Wilson (*Battleships in Action*), she was torpedoed by the destroyer S.90. Exception may be taken, also, to the assertion that the wind-pressure data obtained during the building of the Forth Bridge had not been published at the time when the pylons for the electric Grid were being designed, for they appeared in ENGINEERING of February 28, 1890, accompanied by illustrations of the recording apparatus. These, however, are only trivial inaccuracies in a volume which covers an exceptionally wide field, and are mentioned here rather as amendments than as criticisms. Mr. Mavor has been fortunate in his friends, and they, in turn, have been not less fortunate in their chronicler.

The Alloys of Iron and Chromium. Vol. II. *The High-Chromium Alloys.* By A. B. KINZEL and RUSSELL FRANKS. London: McGraw-Hill Publishing Company, Limited. [Price 40*s.*]

THE series of publications entitled *Alloys of Iron Research Monographs* are important additions to the literature dealing with recent developments in metallurgical science. This volume is the second part of a review which ably summarises modern researches on the alloys of iron containing more than 10 per cent. chromium, and incorporates data relating to stainless and heat-resisting steels. For the purpose of logical presentation, the corrosion- and oxidation-resistant irons and steels are divided into various groups based on chromium content, structural constitution, and, sometimes, properties; but, to obtain a clear understanding of the text, it is desirable to refer to Part I, which gives a broad outline of iron-chromium alloys. The general effects of chromium in iron and steel of both high and low chromium content are discussed in Chapter V of Part I, and the reader who is not thoroughly versed in this field is recommended to study that chapter. The results of fundamental studies of alloy structures indicate that the matter is still in a state of flux; even basic conceptions are passing through a process of evolution, and many of the hypotheses advanced still require considerable study before any degree of finality can be reached. Proper comprehension of phase relations is essential to an understanding of the various phenomena characteristic of high-chromium steels, and, indeed, most of these phenomena have been directly related to phase changes. Although the chemical reactions from the standpoint both of equilibrium conditions and of reaction rates are well understood, the application of this knowledge is still more an art than a science.

The authors discuss the problems involved in the melting of high-chromium steels and the fabrication of complex alloys containing up to 30 per cent. chromium, and survey the low, medium and high-chromium steels, containing 10 per cent. to 18 per cent. chromium. Although a number of special processes have been developed to introduce chromium into the melt in some form other than low-carbon ferro-chromium, this is still the standard process of melting, and is responsible for the largest tonnage of stainless steel produced to-day. The low-carbon 10 per cent. to 14 per cent. and 15 per cent. to 18 per cent. chromium steels are among the most important stainless steels from the standpoint of industrial uses. While the effects of numerous additional alloying elements on the 20 per cent. to 30 per cent. chromium steels have been determined, the composition of the bulk of wrought steels made for commercial consumption has remained practically unchanged since their introduction to commerce. Surprisingly few changes have been made in the composition of the cutlery steels since they were first produced by Brearley in 1914. Throughout the volume the authors indicate the modern trend of research in this complex field of metallurgical science. High-chromium cast irons are relatively unresponsive to heat treatment, but this characteristic is one that renders them useful for elevated-temperature service. In general, corrosion resistance is improved by nickel, but the nickel renders the steel austenitic, and, as discussed in Chapter IX, some austenitic chromium-nickel steels tend to revert to ferrite at moderately elevated temperatures. The volume concludes with a survey of high-chromium manganese steels and iron-chromium-aluminium steels. A valuable feature is the comprehensive bibliography, covering more than 500 articles published during the years 1890 to 1939.

Hoisting Machinery. By WILLIAM H. ATHERTON, M.Sc. London: The Technical Press, Limited. [Price 32*s.* 6*d.*]

ABOUT a quarter of a century ago, the late Mr. Joseph Horner, for many years a prolific contributor to ENGINEERING, wrote a small book on the subject of hoisting machinery. The present work was designed originally as a revised edition of Horner's survey, but the modernisation found to be necessary was so extensive that the result may be regarded as a new book, which forms a self-contained and valuable treatise for both student and engineer. The scope is wide, ranging from simple cranes to the Goliath, Titan and Mammoth types, and giving due consideration to that great labour-saving machine, the light mobile crane; the author has not, however, followed the traditional method of leading up to the main subject by way of such fundamentals as hoisting tackle, and the various combinations of pulleys, but proceeds at once to machinery which incorporates all the methods of hoisting. Stackers and tiering machines for both intermittent and continuous duties are considered, and the study includes all the various types of petrol, petrol-electric, Diesel-electric and electric cranes, and the alternative uses of some types as grab excavators or as shovels for loose material.

In considering the requirements of students and amateur mechanics, Mr. Atherton points out, he has taken some pains not to make the book too academic in style: though it may be suggested that a price of 32*s.* 6*d.* rather limits its opportunities in these fields. To the technical man in the drawing office, however, there is much that will appeal. The designer will probably wish for more information on structural mechanics, and as the whole subject is one of the effect of moving loads, employing influence lines, this part of the book might have been made more comprehensive. The descriptive tendency is rather characteristic of the book, but compensation is provided in a useful bibliography of more exclusively technical literature, including the relevant British Standard Specifications, and in numerous foot-note references to descriptions of particular cranes in the technical Press.

Passing from the general to a few points of detail, mention may be made of the comparison, in Chapter XIX, of the Wylie and the Toplis methods of level luffing, the relative advantages of which are treated at considerable length; and of the chapter on slings, skips, grabs and lifting magnets, in which is collected a mass of miscellaneous information of the kind which may appear to be common knowledge, but which frequently is not so commonly diffused. There are several references in different parts of the book to the varying practice in nomenclature, a disadvantage by no means peculiar to hoisting and hauling machinery, and probably unavoidable in any class of plant that is so widely distributed. It is rather unfortunate that Fig. 62 should illustrate a wooden jib, as all timber has been prohibited as stress-bearing material in cranes for some time past, at least in this country, although there are still a few wood members to be found in use. In the notes on wire ropes, the comment is made that wire rope is safer in use than chain, because it gives warning of failure by stretching; this is true of the usual forms of wire rope, but the new type of non-twist rope seems to lack this useful characteristic. In conclusion, it may be said that the book provides a serviceable general survey of the subject, readably written and commendably free from padding, although some may feel that the author's rather curious use of italics, not only for emphasis but apparently to indicate merely conversational inflections, is somewhat distracting.

EVALUATING THE SURFACE FINISH OF METALS.

By J. GUILD,* A.R.C.S., D.I.C., F.Inst.P.

EXPERIMENTS at the National Physical Laboratory have led to the construction of an instrument for assigning numerical values to the surface finish of metals. The instrument is simple in construction and use, and quick in operation. The first model is intended for the examination of approximately flat surfaces, such as rolled metal sheets, but it should be possible to apply the principle used to the measurement of cylindrical and other surfaces.

The construction of the instrument is shown in Fig. 1, opposite. The base *c* of the instrument rests on the metal sheet to be tested. In the base a circular opening *b* exposes the area (about 10 mm. by 5 mm.) of the sheet to be measured. The body of the instrument consists of a hollow sphere *a*, whitened inside. Light from a small electric lamp *e*, which is a 12-volt 48-watt motor-headlight bulb, passes through an opening into a tube *d*, the interior of which is blackened, and is then focused by means of a lens *f* on the exposed part *b* of the sheet *g*. Some of this light is reflected in a particular direction, as by a mirror, and some is scattered; the smoother the surface the greater is the first or specularly reflected part, and the less the second or scattered part. The instrument is used to compare these two portions.

The quantities measured are the currents produced in a photo-electric cell *h*, which is built into the instrument, when light falls on it. The scattered light falls on all parts of the sphere surface, and thus always illuminates the photo-electric cell. The regularly reflected light may either fall upon a white diffusing surface at *j*, so that the surface of the sphere is illuminated by both the light regularly reflected at *b* and the scattered light; or, by means of the lever *l*, a black cell, illustrated in Figs. 2 and 3, can be moved to *j* to receive and absorb the regularly reflected light, in which case only the scattered light from the sheet *g* illuminates the cell *h*. The side portion of the front plate of the absorbing cell provides the white diffusing surface just mentioned. The measure of the surface finish depends on the ratio of the galvanometer deflections obtained with these two receivers in the position *j*. It should be noted that *j* is located where an image of the opening in the tube *d* is formed by refraction at *f* and reflection at *b*. A white screen at *i* prevents the photo-electric cell from "seeing" the sheet *g* directly.

In addition to the light scattered by the specimen under test, some further light will be scattered within the sphere, and it is therefore necessary to determine the zero from which the galvanometer deflections are read. To this end, the galvanometer scale is adjusted to read zero when the window *b* rests on a black hole of simple construction. If *t* and *d* are the values of the total reflected light and of the scattered light alone as determined from the galvanometer deflections, the quantity used as a measure of surface quality is $1 - \frac{d}{t}$. This quantity, without any correction, will probably serve for most industrial purposes, where the object is simply to grade surfaces in the correct order. Where absolute values on a defined scale are required, various corrections are necessary which it is proposed to describe in a fuller publication elsewhere. The quantity thus determined is the ratio of the specularly reflected light to the total reflected light and is conveniently termed the $\frac{S}{T}$ ratio.

To establish a scale of surface finish two reference standards are employed; a perfectly diffusing surface of magnesium oxide, *i.e.*, a perfectly mat surface, gives the zero point of the scale; and a perfectly polished surface of thin optical glass silvered on the back is assigned the value unity. It is unnecessary to consider here a number of points which arise in testing and calibrating the instrument. When it is desired to discriminate between highly polished surfaces, it is advantageous to change the resistance in the galvanometer circuit

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to secure an open scale when the small quantity d is measured. The apparatus provides an extremely rapid means of testing surfaces. A single determination, including the calculation of the result, takes less than a minute. It is therefore practicable without expending much time to measure various parts of the surface, and thereby obtain not only a representative value for the specimen, but also a measure of the uniformity of the finish. The instrument will reveal variations in smoothness which are quite undetectable by eye, and differences considerably less than the point to point variations over surfaces finished by the best industrial processes can be measured. It will differentiate between properties taken across and along the "grain," where the process of manufacture produces a directional effect. The apparatus is thus sensitive enough for all practical requirements. Some typical results given in Table I show the positions on the smoothness scale of a number of familiar types of surface finish. In this table the two columns headed par. and perp. refer to measurements with the plane of incidence respectively parallel with and perpendicular to the surface markings where these were directional. The values include the corrections not described in this article.

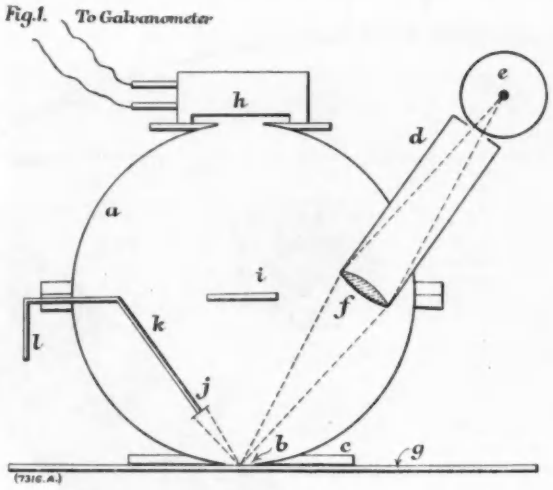


Fig.1.

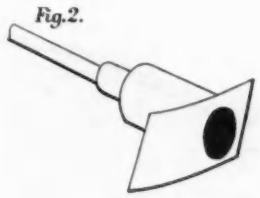


Fig.2.

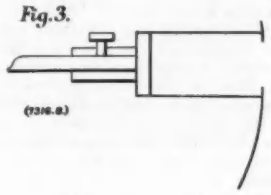


Fig.3.

TABLE I.—*Smoothness of Miscellaneous Surfaces.*

Description of Specimen.	S/T Ratio.		
	Par.	Perp.	Mean.
Standard mirror surface described in text	—	—	1·0000
Optically-polished stainless-steel mirror (new)	—	—	0·9965
Buffed nickel plate of quality used in celluloid pressing	0·9944	0·9932	0·9938
Stainless-steel knife blade, best quality (new)	0·9872	0·9849	0·9860
End gauge (new)	—	—	0·983
Brass sheet; special "R" quality	0·978	0·973	0·975
Cast-iron surface plate, best lapped finish (new)	—	—	0·780
Brass sheet; ordinary good finish, 60 : 40 quality	0·736	0·724	0·730
Milled brass plate; cutting speed, etc., unknown	0·620	0·566	0·593
Brass strip; drawn only from 15 gauge	0·480	0·514	0·497
Brass sheet; low-grade surface	0·477	0·501	0·489
Mat surface of stainless steel prepared on grinding table with S.I.R.A. abrasive, grade B	—	—	0·010
Whatman filter paper No. 1, single sheet	—	—	0·004
Plaster of Paris powder	—	—	0·000
Magnesium oxide smoked on metal base	—	—	0·000

Clearly the utility of the figure obtained with this instrument for the quality of surface finish must be established by comparison of the values with grading made by expert workers in particular industries. The requirements may well vary considerably from one industry to another, and it is important that tests should be made to cover a much wider range of industrial products than has so far been possible. Many specimens have, however, been obtained from firms dealing with very diverse materials, and in no case has it been found that grading according to this test gave an order different from that in which specimens were arranged by expert workers in the several industries; neither has it failed to measure differences they considered significant. While the existing evidence, therefore, does not establish that the numerical index obtained is adequate for general industrial requirements, it suggests that more extensive trials will very probably prove the index to be adequate. If this position can be established by measurements on flat surfaces, there will be justification for adapting the principle to instruments for measuring the finish of other surfaces, and instruments suitable for workshop use could be produced to meet industrial requirements.

EARTHING PRACTICE AND PROTECTION FROM SHOCK.

AN informative paper on "Grounding Practice in Electric Systems with Particular Reference to Protection from Shock," was presented before a recent meeting of the Engineering Institute of Canada by Mr. W. P. Dobson, chief testing engineer of the Hydro-Electric Power Commission of Ontario. The primary aim in earthing electric power systems, the author said, was to prevent damage to equipment and to protect the workman and public against shock. Its secondary function was to assist in the operation of the system. These aims were sometimes conflicting and resulted in the practice varying in accordance with individual opinion and local conditions. While, therefore, the principles of earthing had been understood for many years, it had not been possible to establish general rules not subject to exceptions, nor to apply them without the exercise of judgment based on experience.

From the point of view of personal safety, current was of greater significance than voltage. In order to prevent fatalities from electric shock, it was necessary that the current through the human body should not exceed safe limits for a definite period of time. This current was fixed by the potential difference between the conducting parts with which two portions of the body might come in contact. Differences of potential might exist between parts of an electric circuit and metal objects in the vicinity, or between metal objects and the earth, or between the circuit and the earth. It was these values which constituted the possible danger; and were thus more important than the absolute potential of the circuit. It was important also to distinguish between two conditions which might produce a hazard. Differences of potential might exist between conductors which were insulated from one another, the values depending upon the charges on the conductors and the electrostatic capacity between them. Differences of potential might also exist between points of an electric system in which current was flowing. In this case, the potential difference was determined from the current flow and the impedance between the points. For an accident to occur exposed metal surfaces must be raised to a dangerous potential, a person must touch them and at the same time make contact with the earth or with some other conducting surface at earth potential, the protective gear must fail to function; and all these conditions must occur simultaneously. To prevent this simultaneous occurrence, the insulating materials must be maintained in a good state of repair and the necessary protective measures must be taken to prevent the existence of dangerous voltages on exposed metal surfaces. As a further safeguard, means must be provided, should such voltages occur, for reducing the possibility of a current of dangerous magnitude passing through the body of any person touching such an exposed surface.

The passage of an electric current through the human body caused paralysis of the higher nerve centres. This resulted in the cessation of breathing, prevented the normal reflex response and caused lack of tone of the blood vessels. The heart might be thrown into ventricular fibrillation causing it to quiver rather than to beat. As a result of investigations, the opinion was largely held that currents of from 10 to 20 milliamperes could be endured for less than 1 second by normal human beings without dangerous consequences. By some, however, the value was placed as low as 0·3 to 0·4 milliampere, while others estimated that the minimum current which could be perceived was about 1 milliampere. Others again, claimed that the threshold of fibrillation, which would always cause death, was 100 milliamperes. The time of occurrence of the shock was important. If shock occurred during a certain portion of the heart cycle occupying about 20 per cent. of the total period, much lower currents would be more dangerous than if contact was made at another instant in the heart cycle. The frequency of the shock current was also said to be important. One authority stated that the threshold of fibrillation at 25 cycles was 25 per cent. higher than at 60 cycles and with direct-current five times as great as at 60 cycles. For shocks of short duration, 0·1 second and less, the effect of frequency was less marked. The duration of the current as well as its actual value was an important factor. This was recognised in the regulations of the Canadian Electrical Safety Code respecting electric fences, in which milliampere-second values were incorporated. This code limited the leakage current to 8 milliamperes in fence controllers of the continuous type. In Germany, the maximum leakage current permitted was 0·35 milliampere, and in Switzerland 0·4 milliampere. The Canadian Electrical Code specification for mains radio receivers set a limit of 1·5 milliamperes for the leakage current from exposed metal parts to earth. The Verband Deutscher Elektrotechniker stated that condensers for protection against shock must not permit leakage greater than 0·4 milliampere when installed during factory construction, and 0·8 milliampere if added subsequently. The fixing of values was sometimes complicated by conflicting requirements. For example, those governing radio interference might conceivably permit leakage currents beyond the values which some authorities regarded as dangerous. It was thus apparent that much research was still necessary in this field and regulations should follow conservative lines and provide adequate factors of safety.

The trend in the United States and Canada was to employ earthing on high-tension transmission and distribution systems, though in Ontario the Hood system, in which the primary and secondary neutral points were connected to a common wire, was universally employed for extensions. At present all transformers, lightning arresters and services were earthed, but there was considerably diversity in earthing of exposed metal parts. As regards distribution systems working at pressures exceeding 150 volts, earthing was governed by the Safety Code regulations so far as customers' premises were concerned. In general, these regulations required the earthing of the neutral conductor or the neutral point of the transformer secondary, or, if no neutral were used, the conductor which would establish the lowest maximum voltage to earth. The Code also recommended that all neutrals be solidly connected throughout the system. The neutrals of direct-current three-wire systems must also be earthed, but this connection must be made at the substations only and not on consumers' premises. The primary reason for this was that multiple earths on direct-current systems might aggravate troubles caused by electrolysis. Further, direct-current systems were frequently run underground and were not exposed to contact to the same extent as alternating-current systems. The Code permitted inspection authorities to waive earthing requirements, if it was impracticable to obtain the resistance to earth required by the Code.

The earthing of non-current carrying metal parts presented many problems in which local conditions were of great importance. Practice which might be satisfactory in some cases might be hazardous in others. The difficulties consisted in harmonising operating with safety requirements. The result had been a wide diversity in details of practice depending upon the relative weight attached to these two factors. Two essential factors which must be considered were the magnitude of the potentials and the duration of exposure. Non-current carrying metal parts might acquire potentials in several ways, each of which resulted in exposure of various duration. Induction between circuits might be responsible for voltages of varying magnitude which endured as long as the circuits were alive and were thus continuous hazards. Leakage through insulation was probably the most common cause, while others were lightning either by indirect or direct stroke, and flash-over from live-circuits

or contact with live wires. In connection with earthing problems, the potential gradient was most important and, if not duly considered, serious hazards might be introduced by apparently satisfactory earth connections. In all types of earth connection the voltage gradient was higher nearer the connection than at distant points, and accidents had been caused by contact with earth electrodes in which the difference of potential had been beyond safe limits. Bonding of neighbouring exposed non-current carrying metal parts was often effective in reducing these potentials.

All overhead lines and structures were potential sources of hazard and the difficulty of protecting them was increased by the fact that their location was governed by load demands rather than by the possibility of obtaining low-resistance earths. The earthing of underground structures was often supplemented by bonding where low resistances were obtainable. On the other hand, it might increase electrolysis troubles. There was considerable diversity of practice in the earthing of pole fittings. Some engineers favoured the earthing of metal insulator pins, switch handles, transformer cases, etc., to the neutral and to a common earth. Others objected to earthing certain fittings owing to the operating difficulties that were introduced. The bonding of metal parts on pole tops at substations ensured that these parts were at a common potential, but hazards to workmen might be introduced if adequate clearances were not maintained from live parts. The connection to earth was very important and reliance should not be placed on a single earthing conductor. At least two should extend down the pole and should be guarded from mechanical injury so as to minimise the chance of a broken connection.

The primary object of earthing on consumers' premises was to protect persons from shock by limiting the voltage to earth to safe values. The Canadian and American codes, though in accord in principle, differed in detail, and the same might be said of the British, Continental, New Zealand and Australian codes. A perusal of these indicated the necessity for considering local conditions rather than applying general principles universally. In general, the Canadian Electrical Code required the earthing of circuits operating at potentials greater than 150 volts to earth. Earthing was also necessary if the conditions were "extraordinary." By this was meant where danger from mechanical injury, excessive moisture or extreme temperature was present in ordinary dwellings, offices or factories and where danger from corrosive, inflammable or explosive atmospheres existed. The Code also required the earthing of non-current carrying metal parts of certain portable appliances; of the exposed non-current carrying metal parts of lamp holders, switches, plugs and receptacles installed in basements and in all damp places where danger from shock was likely to be present; also of non-portable cooking and heating appliances for all voltages. The impracticability of securing adequate earthing in certain cases and providing for alternatives, such as insulation, isolation and guarding and operation at low voltage were recognised. For example, metal guards of portable lamps, which were frequently used under "extraordinary" conditions, need not be earthed if thoroughly insulated from live parts. It was recommended that portable lamps and tools used in conductive locations in industrial establishments should be supplied at a pressure not exceeding 32 volts through a transformer with a separate secondary winding. On domestic washing machines, where earthing was difficult, the motor must be guarded and mounted on supports which insulated it from the metal frame. Isolation and guarding applied to equipment, such as instruments, meters and relays, where the potential was between 150 volts and 750 volts, and the metal parts were made inaccessible to unauthorised persons. Further, instruments operating at 750 volts and over were required to be isolated and guarded in addition to having the non-current carrying metal parts earthed.

The Code also discussed methods of earthing in detail. Metal frames on stationary equipment were usually conveniently earthed through the wiring system, as the rigid or flexible conduit or the armouring of armoured cable afforded a metallic path to earth. Non-metallic sheathed cable might have an earth wire incorporated in it. For portable equipment, flexible supply cables were now available having an earth wire forming part of the assembly. Polarised sockets were necessary to meet this requirement and would, no doubt, present a problem, particularly in the older installations. Difficulties in the domestic field also arose from the multiplicity of portable apparatus which might be used where moisture was present and where earthed metal parts might readily be touched. It had not been deemed practicable to require the earthing of such devices, though the installation of sockets in bath-rooms was prohibited.

The efficacy of earthing practice depended predominantly upon the characteristics of the electrode. In this connection the particular difficulty resided in the variability of the electrical properties of the soil and the meagre knowledge available of earth characteristics. A great deal of theoretical work had been done in the development of formulæ for the resistance of many types of electrode. These were undoubtedly of great help in securing satisfactory results. The uncertain factor, however, was the resitivity of the earth. This varied so widely with the type and condition of the soil that extreme caution must be used in applying these formulæ. Calculations must be supplemented by tests which took local conditions into account. The Canadian Electrical Code recognised several types of electrode on the basis of their resistances. The most desirable was that which had a resistance of 6 ohms or less. A metallic water piping system for public supply usually met this requirement and was employed wherever practicable. Other recognised types of earth electrodes were: Metallic water piping systems for private supply, if at least 100 ft. in length and buried in the soil; the metallic casings of artesian wells (if the casing was not less than 3 in. in diameter), and one or more earthing rods, connected in parallel if more than one was used. Gas piping might, with certain restrictions, also be used for earthing the non-current carrying metal parts of electrical equipment. Earth electrodes must be placed below the level of permanent moisture. The connections from the equipment to the electrode must be protected from mechanical injury. Special precautions must be taken in the connections between earthing conductors and clamps.

The Canadian Code strongly recommended that all earths be tested at the time of installation and periodically, say, 5 years, thereafter. In New Zealand, undertakings were required to test earths periodically or otherwise give proof that low resistances were being maintained. The practice of using water-supply systems for earthing had recently been the cause of difficulty between water and electricity-supply authorities. About ten years ago, the American Waterworks Association withdrew its approval of the practice of earthing electrical installations to water-supply systems, alleging that the abuse of the privilege was resulting in the flow of excessive and destructive current through the water pipes. The difficulty had been accentuated by recent attempts of the electrical undertakings in the United States to introduce new methods of wiring, in which a bare neutral conductor was incorporated. Changes in water-works practice involving the introduction of mains of non-conducting material, had also increased the difficulty of obtaining low electrode resistance and might have a revolutionary effect on earthing practice, particularly in urban centres.

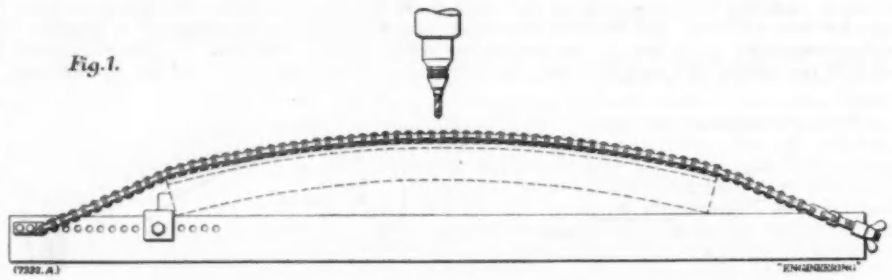
(To be continued.)

THE RENOLD JIG CHAIN.

IN spite of the extension of welding as a constructional process, there are still numerous structures in engineering which, whether riveted or bolted together, involve the drilling or marking-off of long rows of evenly-pitched holes. Boilers, tanks and some bridge members, are examples of such structures and it is needless to particularise further. The ingenious device shown in the accompanying illustrations, Figs. 1 and 2, and known as the Renold jig chain, has been developed by Messrs. The Renold and Coventry Chain Company, Limited, Didsbury, Manchester, to reduce the time required in spacing out such rows of holes and to ensure that their pitch is accurate. The chain can be used on any curved surface provided it has no re-entrant portions, and, of course, on all flat surfaces. All that is necessary is to keep it taut, a condition provided for by a draw-bolt, with a wing nut, at one end and an anchor bolt at the other. The jig chain is shown in detail in Fig. 2, and as used on a curved bar in Fig. 1. From the latter it will be realised that, with this class of work, the chain also acts as a clamp, irrespective of the radius or contour of the curve, different curvatures being accommodated by moving the anchor bolt on the work fixture. Although a drilling

THE RENOLD JIG CHAIN.

Fig. 1.



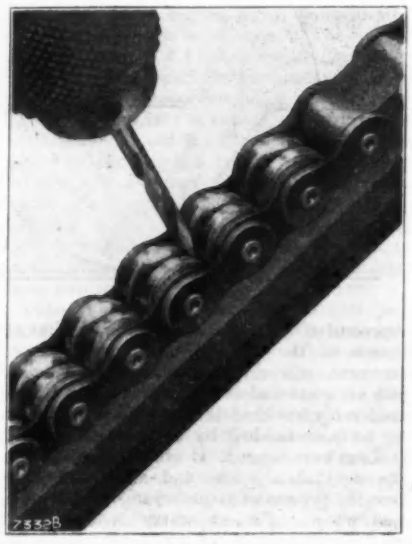


FIG. 2.

is shown in use in both illustrations, it will be clear that the chain is equally serviceable for marking-off, a centre punch of suitable diameter to prevent end or side play being used when precise pitching is required.

The construction of the jig chain will be clear from Fig. 2. It is formed of accurately pitched links, the pins of which carry case-hardened steel rollers, which can rotate freely. The periphery of each roller is formed with a groove having a cross-section which is nearly a semi-circle, so that there is a truly circular hole between adjacent rollers, allowing for the clearance between the rollers. The drill fits closely in this hole and wear on the rollers is greatly reduced by their free rotation as the drill is fed in. The jig chain may be used with the drill in every opening, in which case the pitch of the holes is equal to the pitch of the links when the chain is used on a flat surface. Obviously, the pitch of the holes can be varied as desired, provided it is a multiple of the chain pitch. On a sharply-curved surface the hole pitch will naturally be less than the chain pitch as the centres of the rollers will be at a larger radius than the surface over which the chain is stretched, but the difference will be negligible. The jig chains are made, at present, in five pitches, viz., $\frac{3}{4}$ in., $\frac{1}{2}$ in., $\frac{3}{8}$ in., $\frac{1}{4}$ in. and 1 in., each pitch, with the exception of the smallest, being available with a choice of rollers admitting one of three sizes of drill; for example, the $\frac{1}{2}$-in. pitch chain can be supplied for drills either 0·1285 in., 0·159 in. or 0·191 in. in diameter. Each chain is provided with a solid block near one end, upon which block the pitch and drill diameter are stamped. The position of this block is shown in Fig. 1, and the block itself can be seen in the top right-hand corner of Fig. 2.

REGULATION RELATING TO HIGH-FREQUENCY APPARATUS.—A Defence Regulation has been made requiring every person who has in his possession high-frequency apparatus with a maximum power output exceeding 10 watts at a frequency exceeding 10,000 cycles per second, to notify the police. The regulation does not apply to wireless transmitting or receiving apparatus, the normal type of violet-ray equipment, infra-red, ultra-violet and X-ray apparatus, or to the wavemeters and low-power testing oscillators used by radio dealers. The Home Secretary has also made an Order prohibiting enemy aliens from possessing any such apparatus without a permit.

150-KW PORTABLE DIESEL GENERATING SET.

MESSRS. JOHN FOWLER AND COMPANY (LEEDS), LIMITED, LEEDS.

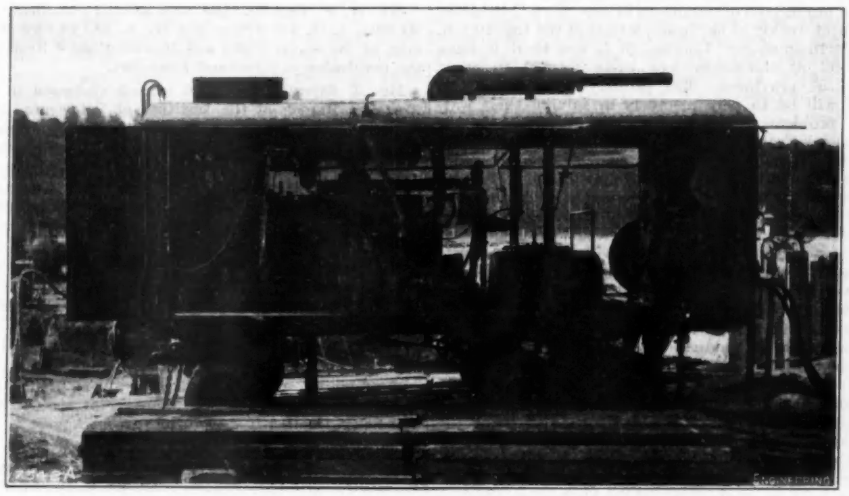


FIG. 1.

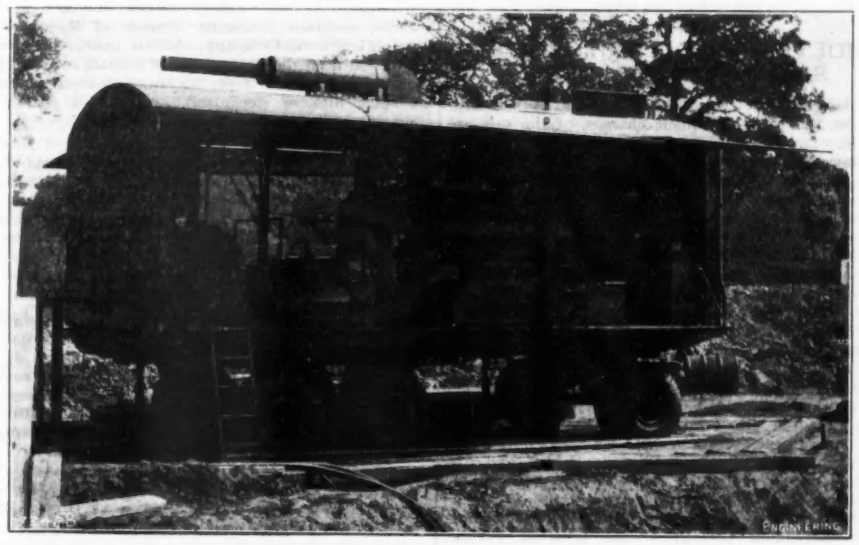


FIG. 2.

150-KW PORTABLE DIESEL-ENGINE GENERATING SET.

ALTHOUGH there may be some apprehension with regard to the possibility of interruption of water supplies from enemy action, such apprehension is largely groundless, as most water authorities are fully alive to their responsibilities in the matter and have taken adequate precautions. A case in point is that of the Mid-Wessex Water Company, who, in addition to other measures, have installed standby pumping equipment, in the form of an electrically-driven borehole pump, at three of their main pumping stations, which were selected as being the best situations from which adequate emergency water supplies could be provided over the area under their control. The three borehole pumps involved are, of course, not portable and naturally require generating plant for their electrical supply. This supply is furnished by the interesting 150-kW portable Diesel-engine driven generating set shown in the accompanying illustrations. The set was constructed by Messrs. John Fowler and Company (Leeds), Limited, Leeds, to the specification of Mr. Claude Pain, M.Inst.C.E., the managing director and chief engineer of the water company. It will be clear from the illustrations that the set is mounted on a strong six-wheel road chassis, and should any of the three selected pumping stations be put out of action, it could be readily towed to the site of the breakdown, where it would be immediately set to work to generate power for the emergency borehole pump installed there. In this way, an adequate water supply could be delivered to the mains until the affected pumping station was restored to normal working conditions.

Dealing with the trailer first, it may be noted that it is not a lorry or other commercial vehicle adapted to a special purpose, but was designed for the generating set by Messrs. Fowler. It is approximately 19 ft. 9 in. long by 8 ft. 6 in. wide, the platform being about 3 ft. 6 in. above the road surface and the total height about 12 ft. 6 in. The engine and generator are mounted on a sub-frame which is attached by three-point suspension to the main frame, an arrangement providing a low centre of gravity and satisfactory balance to the whole trailer. Careful attention was given to the load distribution on the axles. All the axles are interchangeable and the two rear axles are fitted with brake drums, rods being used for brake operation in preference to cables and the brake gear being fully compensated on all four rear wheels. The brake gear is normally operated from the side of the trailer by a handwheel, but provision is also made for operating it from the towing vehicle by means of a cable. Twin 29 in. by 8 in. Dunlop pneumatic tyres are fitted to all the wheels. Semi-elliptical laminated springs are used, the springing having full compensation on the rear axles. Four folding screw-jacks are fitted, and are extended when the set is at work, as shown in Fig. 2.

The machinery is completely housed in, and may be run with the sides open, as shown in the illustrations, or closed during bad weather. The roof and ends are permanent structures though a door is provided at one end, seen open in Fig. 1, for access to the radiator. The roof is of riveted galvanised sheet steel with rolled guttering and is supported by eight channel-section stanchions. The sides are each divided into three upward-opening doors with rigid supporting stays. The weight of the whole trailer complete and ready for service is just under 18 tons. It is transported by towing by a 40-h.p. tractor, for the hire of which a standing arrangement has been made with a local firm of haulage contractors. The greatest distance between the pumping stations is about 25 miles and the time occupied in transferring the generating set naturally varies with the distance. A fuel tank is mounted in the roof and has a capacity sufficient to enable the set to be run for 10 hours on full load without replenishment, which is effected by means of a semi-rotary hand pump mounted on one of the roof stanchions at a convenient height for filling the tank from barrels on the ground. The tank has flexible metallic piping which couples it to twin C.A.V. filters on the engine.

The engine is of the six-cylinder Fowler-Sanders Diesel type, rated at 225 brake horse-power at 1,000 r.p.m., and giving 150 kW at the generator terminals. It is designed for heavy duty service and is capable of maintaining its rated output for long periods without demanding skilled attention. The cylinder heads are independent and are of nickel cast iron, with overhead valves and the Fowler-Sanders two-way swirl combustion chamber. The exhaust-valve seats are of Stellite and are removable. The timing gear, situated at the flywheel end of the engine, consists of two independent roller-chain drives, viz., one to the camshaft and one to the fuel-pump gear and governor. The fuel-injection equipment and the electric starter motor are of C.A.V. manufacture, the fuel pump and injectors being totally enclosed by easily-removable aluminium covers. The other details of the engine scarcely call for comment since they follow Messrs. Fowlers' heavy-duty practice, but it may be mentioned that the crankshaft is carried in eight main bearings and has triangular webs to give good balance. Both journals and crankpins are 4½ in. in diameter.

The bedplate is formed with a marine-type dry sump containing two lubricating-oil pumps, one of which draws oil from the crankcase and delivers it to an oil-storage tank through a cooler incorporated in the engine radiator. The second pump draws from the tank and forces the oil through the engine under pressure. The radiator is cooled by a "Sirocco" type fan, and has a multitubular block with cast-steel sides, top and bottom tanks. The fan is belt driven from the crankshaft and discharges through a duct and cowl outside the trailer housing. Special attention has been given to dust-proofing, as the set may have to work in a dust-laden atmosphere. All moving parts are totally enclosed and run in oil, and the engine air inlet is protected by a battery of four "Handy" oil-wash air-cleaners. It will be evident from the illustrations that an exhaust silencer is fitted above the roof of the housing.

The generator is directly-coupled to the engine by a flexible coupling and is a Crompton-Parkinson compound-wound interpole drip-proof machine, having a continuous output of 150 kW at 230 volts, at a speed of 1,000 r.p.m. For charging the engine-starting batteries, an auxiliary generating set is provided. This consists of a radiator-cooled 4-h.p. Fowler petrol engine running at 1,500 r.p.m. and coupled directly to a Crompton-Parkinson shunt-wound battery-charging generator. This engine and generator are mounted on a steel bedplate attached to the main frame of the trailer, the bedplate also carrying a single-cylinder air compressor. The compressor is coupled to the battery-charging engine as required by means of a combined clutch and "Bowden" control. The compressor supplies air for the inflation of the tyres of the trailer. The cubicle seen to the right of the main generator in Fig. 1 houses a switchboard manufactured by Messrs. Brookhirst Switchgear, Limited, Chester. This carries all the essential instruments and controls and, in addition, a ratchet-type pump-motor starter.

The drums seen on each side of the cubicle both carry 60 ft. of flexible cable and are hand operated. The pedestals carrying them are permanently attached to the frame. Each drum has a locking device which enables it to be secured at different positions of each turn. The free end of each cable is provided with a "Niphan" water-tight socket for connection to the pump motor, while a connector plug, of the same make, is fitted to the other end to couple to the sockets on the switchboard. A third cable drum carries the shunt lead to the pump motor so that speed variation on the motor can be effected from the trailer platform. An electrical interlock on the shunt lead ensures that the trips are operated and the current cut off should the lead be pulled out when the motor is running. By arranging the starter on the trailer, it is possible to start the pump motors at the generating set, thus eliminating starters on the pumps and reducing capital outlay. The cubicle houses, in addition to the instru-

ments and switchgear for the main generator, a change-over switch from the main generator to the battery-charging generator, together with the voltmeter and ammeter for the batteries.

The pumps installed at all three of the selected stations are "Spiroglide" units, manufactured by Messrs. The Harland Engineering Company, Limited, Alloa. They are of the vertical-spindle multi-stage, deep-well centrifugal type, and each has a rated output of 1,000 gallons per minute against a total head of 434 ft. The motors are screen-protected and shunt-wound and the terminal box is fitted with plugs to receive the trailing cable and shunt lead from the trailer. Each pumping set is mounted on specially prepared foundations and is connected to the pumping mains so that it is ready for immediate use.

GUIDES TO SOURCES OF SPECIALIST INFORMATION.

THE first of the Aslib War-Time Guides to British Sources of Specialised Information, to which we referred on page 473 of our issue of May 3, has now been published. It deals with Fuel and Allied Interests (excluding Electricity). The purpose of these guides is well expressed in their name. In normal times the work of the Association of Special Libraries and Information Bureaux, and the stream of questions addressed to it, clearly shows the large numbers of organisations and individuals constantly desiring information which can best be obtained by application to some specialist source. One of the important activities of the Association is to indicate the location and nature of these sources. In the present abnormal conditions, when many organisations have moved to new addresses and there is a great increase in the number of individuals working in fields with which they are not closely familiar, this work has increased in importance, and Aslib is rendering a valuable public service in compiling these guides which give information about the present location and activities of the various organisations in the field concerned.

The Fuel and Allied Industries Guide is divided into six sections. The first of these, which is in the nature of a preface, gives brief accounts of the war-time organisation of the fuel industry, which is divided into four branches, coal, petroleum, gas and gas coke. As an example of the type of information given, it may be said that, in connection with the last of these branches, it is explained that the National Federation of Gas Coke Associations, which is concerned with price co-ordination and price fixing, has been recognised by the Mines Department of H.M. Government as the official body acting nationally for gas-coke producers. It is not concerned with export, which is controlled by the Gas Coke Export Association.

Section II of the guide is a list of the names and addresses of sources of specialised information. This section gives particulars of 76 organisations, divided under Government and Municipal Departments, Professional, Research and Trade Organisations; University Departments; and Commercial and Industrial Organisations. The extent and nature of the libraries maintained by the various organisations is stated, and information is given regarding their accessibility to outsiders. The procedure necessary in making application for information and the field covered by information which can be furnished, are also explained. Section III gives the names of periodicals which print abstracts or lists of references. The costs of the periodicals, or of the abstracts, if published separately, are stated. Section IV is a list of trade and technical periodicals dealing with one or other aspects of the fuel industry. Section V covers the transactions of professional organisations, and Section VI is a list of annuals. The total number of entries under Sections III to VI, which are all concerned with published matter, is 74. The price of the guide, which is produced in mimeograph form, is 2*s.* to members of Aslib and 2*s.* 6*d.* to non-members, postage being 2½*d.* It has obviously been compiled with care and thoroughness and should prove of great practical value in a wide field. The address of the Association of Special Libraries and Information Bureaux is 31, Museum-street, London, W.C.1.

THE INSTITUTION OF NAVAL ARCHITECTS.—The Denny Library, in the headquarters of the Institution of Naval Architects, at 10, Upper Belgrave-street, London, S.W.1, has now been completed by the erection of the memorial to the late Sir Archibald Denny, Bart., LL.D., honorary vice-president, and is open for the use of members during the usual office hours. The memorial, which is the work of Mr. L. S. Merrifield, consists of a portrait bust having as background, a laurel wreath surmounted by a globe on which stands a symbolic figure holding a model of a sailing vessel in one hand, and one of a modern ship in the other.

CO-OPERATION IN MUNITIONS PRODUCTION.

WE have been informed that the Institution of Production Engineers has set up a War Emergency Committee to co-ordinate action in all matters relating to the production of munitions of war. This Committee will meet weekly at the headquarters of the Institution, 36, Portman-square, London, W.1, and there is some prospect of sub-committees being formed to assist it in the provinces. The primary function of this body will be to help members in solving their war-time problems, among which the principal is the temporary provision of spare machine capacity. Steps will be taken to see whether such assistance cannot be better organised than at present by collecting the necessary information. Obviously, such a scheme must depend for its success on the co-operation it receives from members and affiliated firms, but there is every indication that this will be forthcoming. Though the activities of the Committee may eventually become very wide, at this stage it seems likely that it will be largely concerned with such matters as machine capacity, the use of substitute materials, designing for more rapid production, and production delays. Members who either need machine capacity or have such capacity to spare are asked to get in touch with the Committee and it is hoped that such voluntary capacity exchanges will be officially encouraged and recognised by the Government. Under the heading of designing for more rapid production it is proposed to consider minor alterations rather than major changes, which might hold up production, while, by pooling machine capacity, technical assistance, labour, and stores, it is hoped to be able to deal with shortages.

MOLTEN-SALT EJECTOR FOR SALT-BATH FURNACES.

IT is generally recognised by users of salt-bath furnaces that fairly frequent changes of the salt are necessary in order to obtain maximum efficiency; contamination of the salt may not only have an adverse effect on the work undergoing heat treatment, but may accelerate the deterioration of the salt container. The removal of the salt by ladling out when molten or by chipping or cutting out when solid is, however, an unpleasant and troublesome operation, which, on this account, is often unduly postponed. With the object of greatly facilitating this operation, Messrs. The Incandescent Heat Company, Limited, Cornwall-road, Smethwick, Birmingham, have recently introduced a "Salt-Solution Ejector," which consists essentially of an inverted U-tube. The shorter suction leg is fully immersed in the molten salt bath and the longer delivery leg is arranged to discharge the salt into an adjacent catch pit, below the furnace floor, or into other convenient storage receptacles. The entire unit is portable and can be readily assembled and dismantled as required. It may be suspended above the salt bath, or, if working space permits, it can be made a permanent fixture and fixed to the bath casing.

The horizontal portion of the inverted U-tube, between the suction leg and the delivery leg, is connected, by means of a small-bore copper tube, to a control unit in the base of which is an air-suction pump driven by a small electric motor. The outflow of the molten salt, which may be intermittent or continuous, is controlled by means of a valve at the foot of the delivery leg of the ejector, this valve being regulated from the control unit. We understand that the control unit is manufactured in several standard sizes, the largest of which is capable of giving a maximum continuous discharge of 25 tons of molten salt per hour. At present, the salt is cut out from the catch pit after freezing, and, for this purpose it is recommended that the pit be divided up in such a manner as to enable the contents to be lifted out in blocks of a few hundredweights each. We are informed, however, that the firm has under development a special injector which will operate in conjunction with immersion heaters. This will allow the salt to be returned to the salt bath in molten form.

ROYAL SOCIETY OF ARTS.—A legacy of 100*l.* bequeathed to the Royal Society of Arts by the late Mr. Llewelyn B. Atkinson, a former Chairman of the Council of the Society, has been devoted to the provision of a lecture every three years, preferably on some subject connected with electrical science or engineering.

INCREASED CANAL CHARGES.—The Minister of Transport has made an Order sanctioning an increase of 10 per cent. in the charges made by the Aire and Calder and the Calder and Hebble Navigation Companies. Increased charges by the Grand Union Canal Company are also authorised.

PERSONAL.

PROFESSOR J. W. COBB, who retired last year from the Livesey Chair of coal, gas and fuel industries at the University of Leeds, is to have conferred upon him the honorary D.Sc. degree.

MR. W. F. FENNELL has been elected chairman, and MESSRS. A. G. THOMPSON and W. A. EVANS vice-chairmen, of the South Wales and Monmouthshire Branch of the Institution of Structural Engineers.

MR. J. CUTHILL has been elected chairman of the Northern Branch of the Institute of Petroleum, Manchester. MR. J. S. PARKER is to be the first chairman of the new Branch of the Institute at Stanlow, Cheshire.

MESSRS. THE AIRSCREW COMPANY, LIMITED, Weybridge, Surrey, have transferred their sales department to Grosvenor Gardens House, London, S.W.1. (Telephone Victoria 4527; telegrams, "Airscrew, Sowest, London.")

SIR ATUL C. CHATTERJEE, G.C.I.E., K.C.S.I., has been re-elected Chairman of the Council of the Royal Society of Arts, 6-8, John Adam-street, London, W.C.2, for the year 1940-41.

MR. J. RANDLE, M.Eng., has resigned his position as engine works manager of Messrs. Lobnitz and Company, Limited, engineers and shipbuilders, Renfrew, to take up the duties of works manager of Messrs. Kryn and Lahy, Limited, Letchworth, as from August 1.

The University of Liverpool has conferred the degree of Master of Arts, *honoris causa*, upon MR. GEORGE RICHARD CRITCHLEY, general manager of the Liverpool and Glasgow Salvage Association, whose paper to the Institution of Naval Architects on "The Salvage of H.M.S. Thetis" is reproduced on page 56 of this issue.

After an association extending over 60 years, MR. T. SARSON, assistant managing director of Messrs. The Stanton Ironworks Company, Limited, near Nottingham, has retired from the service of the Company. To fill the vacancy, MR. P. H. WILSON has been appointed assistant managing director (technical), and MR. A. WATSON, assistant managing director (commercial).

On Monday, July 8, at the Atlas Works of Messrs. Thos. Firth and John Brown, Limited, Sheffield, MR. EDWARD DIXON, the sales director of the company, was presented with his portrait in oils, painted by Captain Oswald Birley, R.O.I., to mark his completion of 50 years' service. Mr. A. J. Grant, managing director, presided, and the presentation was made by Mr. John Smith on behalf of the 937 members of the Staff Society who had subscribed for the portrait to be painted.

Included in the King's Birthday Honours are awards of the C.B.E. to LIEUT.-COL. A. F. ST. CLAIR COLLINS, A.M.I.Mech.E., R.A.S.C., COL. (temp. BRIG.) J. S. CRAWFORD, M.I.Mech.E., late R.A.O.C., and LIEUT.-COL. (acting BRIG.) D. J. MCMULLEN, D.S.O., M.I.Mech.E., R.E.; of the O.B.E. to LIEUT.-COL. E. N. W. BIRCH, A.M.I.Mech.E., R.A.S.C., LIEUT.-COL. H. M. CADELL, M.I.Mech.E., R.E., CAPT. (acting MAJOR) A. A. CLEMENTS, B.Sc., A.M.Inst.C.E., R.E. (T.), LIEUT.-COL. C. L. H. HUMPHREYS, T.D., M.Inst.C.E., M.I.Mech.E., R.C.S. (T.), LIEUT.-COL. B. H. LEESON, T.D., M.I.E.E., late R.E. (T.), and MAJOR (acting LIEUT.-COL.) G. A. SIMS, A.M.I.Mech.E., R.A.S.C.; and of the M.B.E. to LIEUT. (Asst. Ordnance Mech. Engineer) R. REID, A.M.I.Mech.E., R.A.O.C. The D.S.O. is awarded to LIEUT.-COL. J. R. KENNEDY, A.M.Inst.C.E., A.M.I.E.E., R.E. (T.).

TENDERS.

WE have received from the Department of Overseas Trade, Great George-street, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained on application to the Department at the above address, quoting the reference numbers given.

Steam Turbo-Alternator Set, 50,000 kW, for Bunnerong Power Station. Sydney County Council, Sydney, New South Wales; October 24. (T. 16,057/40.)

Automatic Step Voltage Regulators, two, outdoor, oil-immersed, for use in connection with a 2,000-kVA, 33,000-volt, three-phase, 50-cycle feeder. City Electric Light Company, Limited, Boundary-street, Brisbane, Australia; August 13. (T. 19,607/40.)

Electric Tubular Heaters, comprising 32 six-ft., 8 four-ft. and 56 two-ft. double-tier heaters, for Cape Town City Infectious Diseases Hospital. Electricity Department, Cape Town; September 5. (T. 20,785/40.)

Copper Binders and Tapes. Post and Telegraph Department, Wellington, N.Z.; September 2. (T. 20,805/40.)

Electrical-Distribution Material. With reference to the call for tenders for electrical-distribution material, noted on page 562 of our issue of June 7, we now learn that the Electricity Department, Salisbury, Southern Rhodesia, has postponed the closing date from July 15 until August 12. (T. 19,595/40.)

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Supplies have not been quite so freely available on the Welsh steam-coal market during the past week, and the general tone has shown some improvement. This has been due, in the main, to a much brisker request from inland users following the increased industrial activity. In addition to requiring more coal to meet their present needs, industrial users were also making heavy purchases for stocking purposes in answer to the recent appeal made by Mr. D. R. Grenfell, Minister of Mines, that they should lay in stocks as a precaution against any repetition of the interruption of transport that took place during the severe weather of last winter. A good demand was also circulating in the market from overseas users. Prospects of a large scale improvement in deliveries to Portugal were still being discussed, and negotiations were reported to be proceeding between local interests and the Portuguese authorities for a renewal and expansion of the pitwood-for-coal exchange scheme. It has been recognised locally that Portugal will become one of the district's largest customers, and also one of the most important sources of supply of pitwood. South American customers continued to display considerable interest, although it was generally understood that it would be some time before South Wales could reap the fullest advantage of the business available in this direction, since during the time when local shippers were unable to supply these buyers, South American users placed contracts with producers in the United States. Deliveries were now being made under these contracts, and until they expired business would not reach its maximum. Deliveries to Eire were maintained along busy lines, while buyers in Spain were displaying a closer attention. Best large coals were being steadily absorbed, but bituminous smalls were only very sparingly offered. The dry small kinds, however, were quieter. Sized descriptions, particularly the popular kinds, were still scarce. Cokes attracted sustained interest from inland users, but business was difficult to arrange. Patent fuel remained busy.

The Iron and Steel Trade.—Active conditions ruled in the iron and steel and allied trades of South Wales and Monmouthshire last week. Works remained fully engaged, and there was no sign of any diminution in the demand.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The new Order prohibiting the use of steel on non-essential buildings will have little effect on Sheffield. When war broke out, work on building extensions gradually came to a standstill. The Order will not affect the extensions to Sheffield University, as all the steelwork was completed some weeks ago. Sheffield production of structural steelwork has increased considerably during the past few months. The greater part of output is being used for carrying out extensions to steelworks and engineering factories in various parts of the country. In their efforts to supplement scrap supplies, Sheffield Corporation are considering taking steps to dismantle two dozen old water wheels—relics which helped to establish the cutlery industry locally—in Rivelin Valley. A considerable tonnage of iron would result from their demolition. One wheel will be kept intact as an object of interest for visitors. The demand for steel of all types is well in excess of the maximum output. Not only are raw and semi-finished materials in demand, but the call for high-efficiency steels reaches a high level. This applies particularly to acid-resisting steels, tool steel, and steels capable of withstanding excessive wear and heat. Local works have increased outputs during the past few weeks. In the heavy machinery and engineering trades intense activity prevails. Local makers of railway rolling stock now have a better opportunity for developing export trade, and are giving attention to the South American market. Foundries, rolling mills, and forges are all operating at their full capacities. Re-rollers are exceptionally busy. The demand for coal-mining equipment shows a further expansion, and more steel girders and arches are being used by South Yorkshire mines. Makers of steelworks and ironworks equipment have good order books. Among the plants on order are rolling mills, hydraulic presses, and both electric and gas-fired furnaces. The tool trades are operating at high pressure.

South Yorkshire Coal Trade.—The demand for house coal is now reaching winter standards, since many householders are buying for stocking purposes. The result is that stocks at colliery and railway sidings are somewhat low. Industrial fuel is in strong request, and consumers are finding no difficulty in obtaining supplies. Steam coal is a progressive section. There is a good market in foundry and furnace coke.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—The present market conditions are greatly restricting ordinary commercial business, but iron and steel deliveries, under the control of distribution scheme, are providing consumers engaged on war work with a regular tonnage that covers their requirements. The pressure for supplies continues and the producers of some commodities are finding it necessary to run their plant at full capacity.

Cleveland Iron Trade.—The demand for foundry iron is still below the normal, but is steadily expanding. The supply is ample although the parcels of Cleveland pig obtainable are few and small. Deliveries of Scotch iron for the production of commodities that require pig of certain qualities are adequate, but most of the tonnage passing into use in this area is from the Midlands. There is still no prospect of a resumption of the regular make of Cleveland pig, recognised values of which are ruled by No. 3 description at 120*s.*, delivered within the Tees-side zone.

Hematite.—The situation as regards East Coast hematite shows little change. Makers are able to cover the actual requirements of consumers, but have very little iron for other purposes. Production is maintained on a large scale, but is insufficient to supply the expanding demand and a further increase of output in the near future is anticipated. Quotations are at the equivalent of No. 1 grade of hematite at 131*s.*, delivered to North of England customers.

Basic Iron.—No basic iron is yet available for sale; the steelworks owned by the makers are still absorbing the whole of the output. The fixed price of 113*s.* remains nominal.

Foreign Ore.—Foreign-ore consumers are able to keep stocks at an unusually high level and regular imports are expected to continue.

Blast-Furnace Coke.—There are few transactions in Durham blast-furnace coke. Local users have little occasion to buy and sellers are not seeking to add to their contract obligations. The price of good medium qualities is 33*s.* 5*d.* at the ovens.

Manufactured Iron and Steel.—Re-rollers of iron and steel are receiving enough semi-finished material to keep the mills fully employed. The recently-increased make of semies is well maintained and imports are substantial. Finished-iron firms continue to turn out increasing tonnages and finished-steel producers have fully sold their outputs for some months ahead. Among the principal quotations are: Soft billets, 10*l.* 10*s.* to 10*l.* 15*s.*; hard billets, 11*l.* 17*s.* 6*d.*; joists and angles, 13*l.* 13*s.*; heavy plates, 14*l.* 3*s.*; and boiler plates, 15*l.* 0*s.* 6*d.*

Scrap.—All available parcels of iron and steel scrap are readily taken up; more heavy-steel scrap is needed.

THE MESSEL MEDAL.—The Messel Medal of the Society of Chemical Industry, which is awarded once in every two years, was presented to the Rt. Hon. Viscount Samuel at the annual meeting of the Society on July 9. Previous recipients include Professor H. E. Armstrong, F.R.S., Viscount Leverhulme, the Earl of Balfour, K.G., Sir Harry McGowan, Sir Robert Mond and Dr. L. H. Baekeland.

BRISTOL JUPITER ENGINES IN NEW GUINEA.—Messrs. The Bristol Aeroplane Company, Limited, Filton House, Bristol, inform us that a report received recently from New Guinea emphasises the satisfactory performance of the Bristol Jupiter engines employed for air transport between Wau and Salamaua and on other air services in that country. In this connection it is pointed out that the Jupiter engine has not been in production since 1928, that most of the engines used in New Guinea started their service there many years ago as second-hand engines, and that they have since been operated under very strenuous conditions of climate, with little expenditure on spare parts.

TRADING WITH THE ENEMY: FRANCE AND FRENCH TERRITORIES.—The Board of Trade give notice that the whole of French territory in Europe (including Corsica), and Algeria, the French zone of Morocco and Tunisia, is enemy territory for the purpose of the Trading with the Enemy Act. It is accordingly a punishable offence to have commercial, financial or other intercourse or dealings with, or for the benefit of, any person resident or carrying on business in any of that territory, or any body of persons carrying on business in any place, if and so long as the body is controlled by a person resident or carrying on business in that territory. Inquiries on the subject should be addressed to the Trading with the Enemy Branch, Alexandra House, Kingsway, London, W.C.2.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Although the demands of consumers are very heavy, the Scottish steel makers are managing to meet all demands and to maintain the record output figures recently attained. Plant is all running at full capacity, this having been made possible by ample supplies of raw material. The latter have been materially augmented by the response of the general public to the invitation of the Government to collect scrap. Dumps have been formed by county and town councils and many hundreds of tons of scrap have already been collected. Much activity is again general in the shipyards, which are responsible for a large tonnage of steel material. In addition, steel makers are having to supply the heavy requirements of the munition works. Light material is also in steady demand and the black steel-sheet makers are extremely busy on work of national importance. The home trade has required the bulk of the production for some time and export licences were suspended. The position is now better and permission has been granted recently for the shipment of some finished material and it is thought that further permits may shortly be issued. In normal times, all the works in the Glasgow area would be shut down this week for the annual Fair Holidays, but in the present circumstances work is proceeding as usual. The following are the current prices:—Boiler plates, 15*l.* per ton; ship plates, 14*l.* 3*s.* per ton; sections, 13*l.* 13*s.* per ton; medium plates, rolled in sheet mills, ¼ in. and thicker 18*l.* 7*s.* 6*d.* per ton; mild-steel black sheets, No. 21-24 gauge, close annealed, 19*l.* 7*s.* 6*d.* per ton; galvanised plain steel sheets, No. 21-24 gauge, 23*l.* 2*s.* 6*d.* per ton; and galvanised corrugated sheets, No. 24 gauge, 22*l.* 12*s.* 6*d.* per ton.

Malleable-Iron Trade.—A good demand exists for bar iron, and the malleable-iron makers of the West of Scotland are all very busy. The re-rollers of steel bars have sufficient work in hand to keep them fully employed for many months and as the supply of raw materials is ample, there is little likelihood of any reduction in output for some time. Arrangements have been made for forward consignments which should ensure continuous running for the remainder of the year. The current prices are as follows:—Crown bars, 15*l.* 2*s.* 6*d.* per ton; best iron, 15*l.* per ton; No. 3 bars, 13*l.* 7*s.* 6*d.* per ton; No. 4 bars, 13*l.* 12*s.* 6*d.* per ton; re-rolled steel bars (tested), 15*l.* 11*s.* 6*d.* per ton; untested, 15*l.* 8*s.* 6*d.* per ton; angles and tees, 4 in. and under, tested, 15*l.* 1*s.* 6*d.* per ton, and untested, 14*l.* 18*s.* 6*d.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There has been no change in the state of the Scottish pig-iron trade during the past week and the furnaces are being worked at full capacity. The demand remains steady and consumers keep pressing for deliveries in order to maintain their output. Good stocks of raw materials are now held.

EXPLOSIVES IN COAL MINES.—The Secretary for Mines has announced that the explosives Antifrost Nitrox No. 3, Antifrost Nitrox No. 3 (Sheathed); Antifrost Gelammonite No. 3; and Antifrost Gelammonite No. 3, (Sheathed), manufactured by Messrs. Cooke's Explosives Limited, Penrhyndeudraeth, Merionethshire, have been added to the List of Permitted Explosives for general use in mines to which Part II of the Explosives in Coal Mines Order applies.

THE BIRMINGHAM EXCHANGE.—The 1940 edition of the *Directory* of members, subscribers, and representatives of the Birmingham Exchange has recently been issued. The book contains an alphabetical list of members and subscribers, with their postal and telegraphic addresses, telephone numbers, and the names of their representatives; an alphabetical list of holders of admission tickets; and a classified-trades directory. A brief history of the Exchange and lists of its officers, by-laws, etc., are included. Copies of the *Directory* are obtainable, price 2*s.* 6*d.*, from the secretary's office, Birmingham Exchange, Birmingham.

THE INSTITUTION OF HEATING AND VENTILATING ENGINEERS.—The President of the Institution of Heating and Ventilating Engineers informs us that the Institution's competition, whereby premiums up to 10*l.* 10*s.* are awarded for papers submitted and considered of sufficient merit to be published in the monthly *Journal* of the Institution, is now thrown open to non-members. A leaflet containing details of suggested subjects and hints on preparing papers, is obtainable from the secretary of the Institution, 22, Russell-square, London, W.C.1. The closing date for the receipt of entries is October 1. All papers submitted for the competition are eligible also for the Silver and Bronze Medals of the Institution, which are awarded for papers considered to be specially meritorious.

THE SALVAGE OF H.M.S. "THETIS."

(*For Description, see Page 56*).

Fig. 1. TYPICAL SECTION THROUGH No. 1 & 2 HOLDS

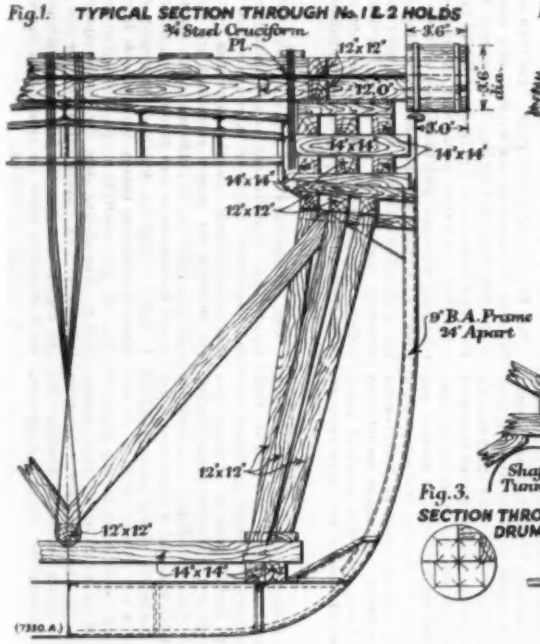


Fig. 2. SECTION THROUGH No. 4 HOLD

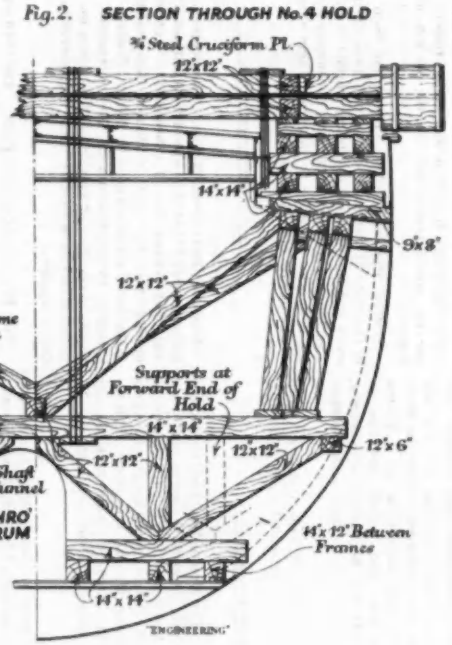


Fig. 3. SECTION THRO' DRUM

14"x12" Between Frames

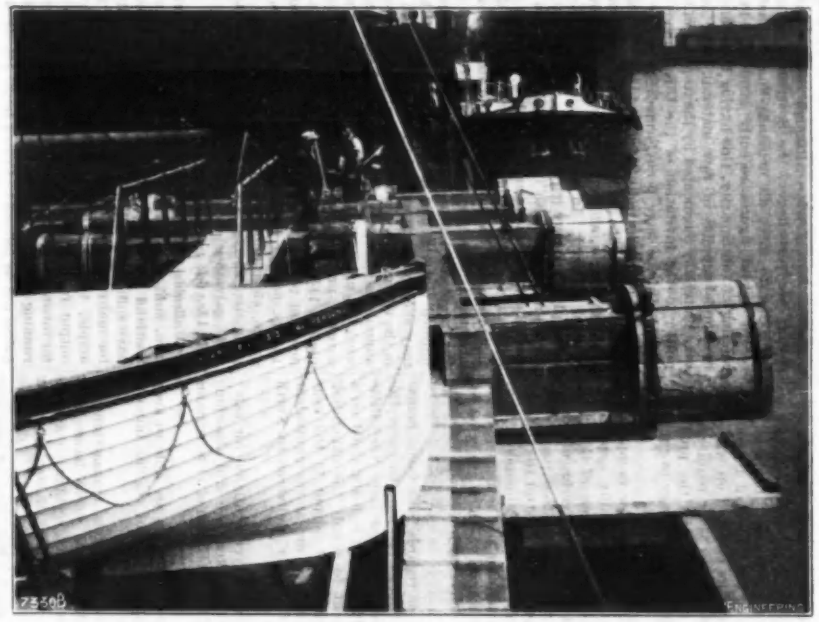


FIG. 4. BEAMS ON DECK OF LIFTING VESSEL.

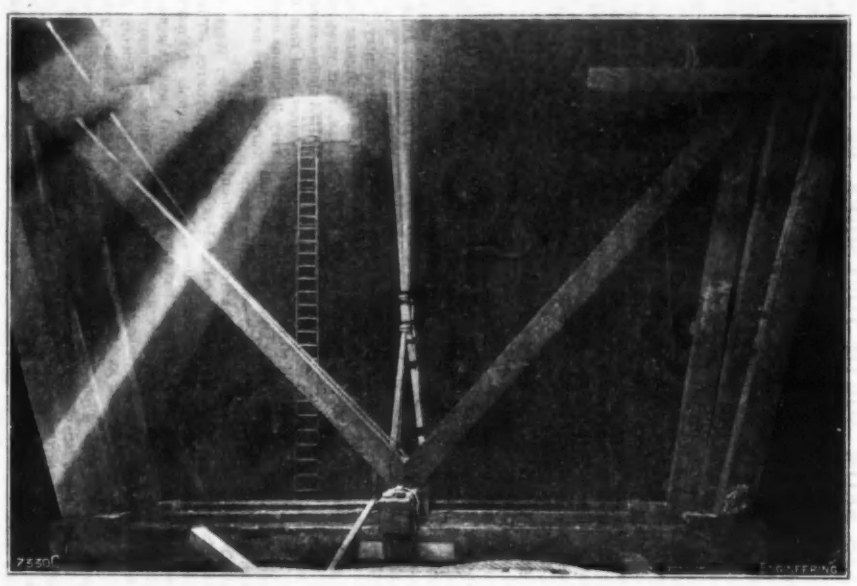


FIG. 5. UNDER-DECK SUPPORTS AND STIFFENING.

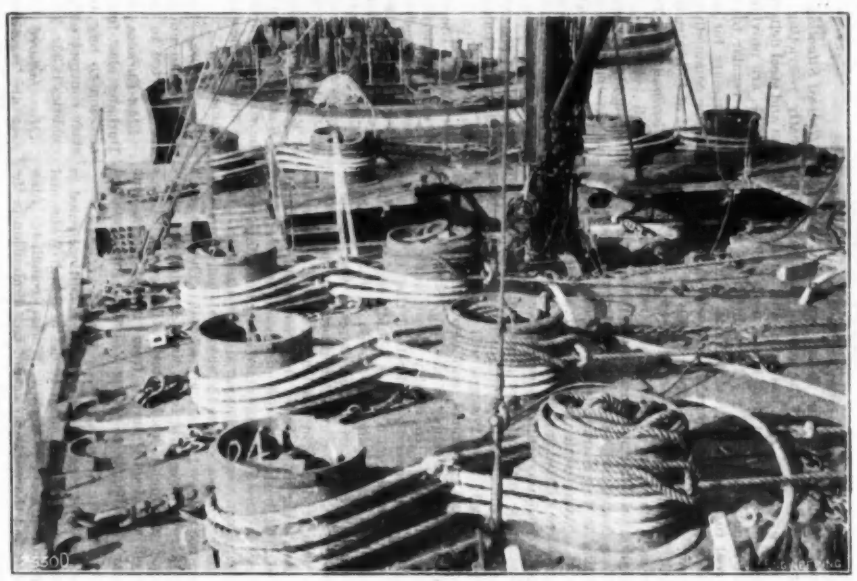


FIG. 6. ARRANGEMENT OF LIFTING WIRES ON BOLLARDS.

ENGINEERING.

Offices for Publication and Advertisements, 35 & 36, Bedford Street, Strand, London, W.C.2.

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Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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TEMPORARY ADDRESS.

For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, JULY 19, 1940.

VOL. 150. No. 3888.

LABOUR AND MATERIAL IN THE ELECTRICITY SUPPLY INDUSTRY.

Two of the recently appointed ministers—Mr. Herbert Morrison and Mr. Ernest Bevin—are exerting all the energy, of which they both possess an abundant supply, to provide the country with the munitions that are so urgently needed and to ensure that the available man power is fully and efficiently utilised for the same purpose. There are few who will not do all they can to further these efforts to the best of their ability. It is true that, in practice, it is sometimes difficult for the individual to do as much as he would wish in these directions, and often he feels that his intellect or his labour is being wasted. The material result is a feeling of frustration, especially among those whose ages lie outside the somewhat arbitrary limits that have been imposed or whose qualifications do not quite correspond with those which, at the moment, are most urgently required. This state of mind is, perhaps, rather to be approved than deplored, and it is to be hoped that, before long, everyone will have been fitted into some niche where he can play a useful part in sustaining and increasing the national effort. At the same time, a word of warning is necessary to those whose impulsiveness may tempt them to change their present position for some other post in which it may seem they can do more than they are already doing to assist towards winning the war. The advice to "stay put" does not apply only to location. It is equally worth acting upon when questions of material and of employment are under consideration.

These reflections have been inspired by the perusal of a circular, recently issued by the Electricity Commissioners, which deals with various questions concerning economies in the use of materials required by electricity undertakings and the release, so far as is possible, of skilled workers for other war industries. These questions have been under consideration with the Joint (Emergency) Committee of the Electricity Supply Associations, so that they may be presumed to have received the general support of the industry. It is evident that the electricity supply industry, like every other, should exercise, as far as possible, greater economy in the use of materials, especially of those which are required for intensifying the national war effort. At the same time, the supply of electricity remains an essential national service if munitions are to be turned out in the required quantity. It may even be necessary, after every step has been taken which will enable those lightly loaded districts to assist those where the demand is steadily increasing, to extend the equipment of certain generating stations and still further to develop the distribution systems. Some compromise is necessary, therefore, and for that reason the Commissioners have made special efforts to discover where it may be most practicable.

This applies particularly to the use of steel. The Commissioners have satisfied themselves that further economies could be effected, without detriment to the security of the supply, by dispensing in the generating stations with steel armouring on metal-sheathed underground cables ordered for future manufacture. To facilitate this procedure, therefore, they have issued a general approval permitting unarmoured mains, consisting of an insulated conductor or conductors and enclosed in a lead sheath, to be drawn into pipes or ducts, to be laid in troughs, filled with composition and covered with tiles, or other protection, or even to be laid directly in the ground, if they are protected with suitable slabs of reinforced concrete, inter-locking tiles or concrete made *in situ*. Even such protection may be omitted where mains are laid at depths of not less than 2 ft. in ground, in situations other than in streets. In fact, they go a step farther: they will be prepared to authorise the allocation of steel for the armouring of cables only in cases where it can be shown to be really essential. It is only fair to say that non-armoured cables have already been adopted in a number of individual instances, but now they will become of universal application. This change, imposed by war-time conditions, may cause some perturbation among the orthodox, but more important modifications in other directions have already been made during the past nine months. It might be argued, indeed, that in the desire to obtain a first-class installation and 100 per cent. safety, we have at times overstepped the boundary between extravagance and economy. If so, this will enable a beneficial change to be introduced.

The circular also points out that economies in the use of materials required for the manufacture of paper-insulated cables can be brought about if electricity undertakings adopt the general practice of ordering this essential part of their material in strict accordance with the requirements of the latest British Standards specification on the subject, and not in compliance with an earlier and rather stricter document. To enable this to be done, the Commissioners have amended the appropriate paragraph in the Electricity Supply Regulations, 1937, an action which, though it may bring about a certain lowering of standards, will not cause any important reduction in the safety of the installations affected. The cable makers have been informed of these decisions, with which they will certainly comply loyally. The Commissioners also express the hope that electricity undertakings will pool all the practical suggestions they may be in a position to make, regarding the more economical use of materials generally. No doubt, this hope also will be fully realised, since its importance will be clear to all concerned.

Turning to the important question of personnel, the Commissioners first refer to a circular which was issued to local authorities some weeks ago by the Ministry of Health. This pointed out that the immediate acceleration in armaments production which is necessary can be best secured by transferring the maximum number of skilled workers from less to more essential work. An appeal is therefore made to local authorities to review their staffs with this end in mind, and especially to make arrangements to retain only the minimum skilled staff which is indispensable for the safety and maintenance of essential local services. If this indispensable nucleus is supplemented by labour of a less skilled kind it should be possible to release some really useful talent for immediate purposes. Steps

in this direction have already been taken. Indeed, it would seem that so great has been the eagerness of those interested to enlist in the munitions industry that considerable difficulties have been placed in the way of the efficient operation of the undertakings. So great, indeed, has been the exodus that undertakings have inquired whether some control cannot be exercised over such transfers. They have been informed that, by the Undertakings (Restriction on Engagement) Order, 1940, employers in the building and civil engineering industries, as well as in general engineering, are required to engage workers only through the employment exchanges or under an approved arrangement made by trade unions under directions from the Minister. Recruitment to the engineering industry, therefore, can be controlled in this way, and the Commissioners are advised that employment exchanges will not transfer a "key" employee from an electricity undertaking to other employment.

Before transferring other employees, the relative needs of the undertakings concerned and their importance in the national interest will be compared.

A pertinent comment on the situation as it exists to-day was made by Mr. Bevin at a luncheon of the National Defence Public Interest Committee last week, when he recognised that the life of the country had to be kept going and declared that non-essential industries would not be closed down before those engaged in them could be absorbed into munitions work. At the same time, these non-essential industries employ much labour which should be transferred before industries like that of electricity supply, which are certainly necessary to the well-being of the country, are placed under contribution. The suggestion that such a weeding out should take place applies not only to private enterprise but to many central and local-government departments as well. The latter, in particular, have been subjected to considerable criticism for permitting so many of their employees to be engaged on apparently unessential work. Such occupations as trimming verges, tending flower beds, and even a great many of the duties that are being carried out on the roads, could easly be temporarily suspended and those employed on them transferred to defence units, as suggested in the House of Commons last week.

It is true that no building or civil engineering works involving an expenditure exceeding 25,000*l.* can now be started without the approval of the Works and Priority Sub-Committee, who may be relied upon to lay their embargo on anything that is non-essential; nevertheless, a multiplicity of small contracts may absorb as much labour as one large one, and it is advisable, therefore, that any work of this kind which is being undertaken should be carefully watched, although with due discrimination to guard against the very real danger of pushing economy to the length where it begins to defeat its own end. The ultimate decision must be left in the hands of the technical executives, who are responsible for maintaining the services in the event of possible breakdown; their staffs must be kept at a strength which is adequate for this purpose, and not merely at the lower level which would suffice for normal supervision.

It cannot be guaranteed, of course, that no skilled labour will be withdrawn from electricity supply undertakings or that the demands will not increase rather than diminish as time goes on. That state of affairs must be accepted with equanimity, a feeling which may be encouraged by remembering one feature of recent electricity history. During the last few years the supply undertakings have come together to a notable extent to assist each other in maintaining the supply of energy, even if the movement has not always been voluntary. Since the war, too, arrangements have been made by undertakings in Greater London and in some other parts of the country for the interchange of spare transformers, switchgear and cables, and for the pooling of skilled labour so that supplies may be restored and damage repaired without delay in the event of enemy action. It is to be hoped that these arrangements will be more widely extended, for in this way it will be possible to do much to solve efficiently the twin problems of labour and material as they affect electricity-supply undertakings.

THE DRAINAGE OF AGRICULTURAL LAND.

THE ploughing of the original two million acres having been recently completed, the Government have extended the scheme, under which a subsidy of 2*l.* per acre is to be paid on all further grassland broken up for re-seeding, until March 31 of next year. As the scheme has now been in effective operation for over a year, it may be assumed to have arrived at the difficult stage; that is, the "easy" lands have been dealt with and only the "awkward" acres remain. It is to be expected that the bulk of the land remaining to be broken up will be stiff to work and in poor heart, and an essential preliminary to the plough, in many cases, will be drainage in some form. This will be helped by another Government scheme, by which the County Agricultural War Committees are to receive a special grant of anything up to 50 per cent. of the cost in respect of the particular form of drainage undertaken by them, and a "substantial grant" will be made towards the mole-draining of a further 2,000,000 acres. The amount of the grant seems, as yet, to be unspecified, but it is hoped in the districts affected that this payment also, will reach 50 per cent. of the cost. Unfortunately for next year's crop, the mole-drainage season is practically over, as by now the land has become too hard. Next spring, however, is on the way, and there is every reason for examining, and reconditioning as may be necessary, all idle tackle, in addition to mustering a sufficiency of new plant, so that an early start can be made next year. Nobody can foretell to what extent this country will be thrown on to its own resources, during and after this war, but it is only common sense to prepare for the worst eventuality, and in this connection the official policy of draining all waterlogged land is to be commended. Cost, in the circumstances, is entirely a secondary consideration. A thought to stimulate early action in anything agricultural is that a missed opportunity often means a year's wait.

Agricultural drainage is a wide term. It covers effective clearance of local streams and brooks, as well as the cutting and maintenance of hedge-ditches in addition to the actual field-drains. Field drains may be piped and, therefore, permanent, or pulled through with a torpedo-shaped "mole," a process requiring periodical repetition, according to the nature of the subsoil, at anything from six-year to twenty-year intervals. The maintenance of brooks and streams is outside the orbit of local agricultural authority, but that of ditches and drains, being the immediate concern of both farmer and engineer, is worth some consideration. In the more prosperous and settled days of farming, hedging and ditching (that is, trimming the hedges and cleaning out the ditches) was a regular winter-time job for the farm hands and was never neglected. The men were paid piece rates, inclusive of a certain number of faggots for home consumption, the operations being carried out by hand with spade and billhook. During the recent severe depression, these maintenance activities have been sadly neglected by even the best farmers, and in many cases have been entirely omitted by reason of lack of funds; in consequence, there is much leeway to be made up, as it is obviously of no purpose to drain the field itself if a proper outlet for the drainage is lacking. Hedging must still remain a hand operation, but ditching calls for a simple machine that we believe, as yet, to be non-existent, in the shape of a lightweight side-bucket dredger, mounted on a creeper track. Side action is necessary, as in the majority of cases it is impossible for the dredger to straddle the ditch on account of the inevitable hedge and bank at one side; a side-action machine could operate without difficulty parallel and close to the ditch on the side where there is no hedge. Such plant would be beyond the means of the average farmer and calls either for the services of a contractor or for Government ownership. It would be necessary to cart away the spoil; if it were spread over the adjacent land the farmer would be presented with a magnificent crop of weeds in the next spring, the amount and strength of the seeds that can be dredged up from ditch-bottoms being difficult to appreciate by those who have not first-hand knowledge of the problem that they present. The possible need, in addition, for an ordinary jib excavator mounted on creepers cannot be entirely ignored, as, in a general survey of a waterlogged area, it might be found necessary to cut new deep ditches across open territory to some central stream or drain, as a part of the general scheme; but these, presumably, would be rare cases, for which existing plant could be readily adapted.

Turning to the consideration of drains, it will probably be found that complete pipe-draining of fields must be ruled out as being too slow and expensive for present conditions; mole-draining, therefore, is the remaining alternative. This is heavy work, the resistance to pulling through average clay soil in early spring, when the soil is moist, being approximately 4,000 lb., using a 3-in. diameter mole at 18 in. deep, or 5,500 lb., using a 4-in. mole at 21 in. Wet soils ease the pull, but dry soils intensify it up to impossibility. The lead-off at the end of the pull presents some difficulty unless the pulling engine can be located on the farther side of the ditch and and the mole pulled right into the ditch. The alternatives are a hand-cut trench and piping into the ditch from the end of the pull, to be filled in after completion, or a similar arrangement, using larger pipes, crossing the lower ends of the series of drains and being carefully joined to each pull in the process of excavation. Some farmers are content to use a larger diameter of mole drain instead of the piping, but even so it is always necessary to ensure a junction by cutting down. As will be seen from the figures quoted, mole-draining is beyond the normal capacity of the standard farm tractor, although it has been achieved by doubling the wire over a pulley, fixed to a temporary anchorage and moved after each pull. It is necessary, therefore, to fall back on the steam ploughing engines, which, admittedly are the better plant for the purpose. Recent suggestions in ostensibly well-informed circles, that available steam tackle cannot be used on account of the shortage of skilled staff, will not bear close examination; there are plenty of retired railway engine drivers willing to take up war work of this nature, as well as travelling-show enginemen, used to the management of steam engines, who, with a little training, would be competent for any work on the land. Admittedly, some organisation is required to bring men and plant together; this is not an impossible task, but it needs immediate attention if the full benefits are to be attained in time to be of service.

NOTES.

IMMOBILISING COASTAL CRAFT.

THE precautions already in force to prevent the use of motor vehicles by enemy agents have now been extended, by an Admiralty Order, to all small craft on that portion of the British coast, extending from Berwick-on-Tweed to the boundary between Dorset and Devon, which comes within the prescribed Defence Areas. The Order, which is entitled the Vessels (Immobilisation) Order, 1940, also extends, to all vessels in tidal waters or in docks round the entire coast of the United Kingdom, the requirement that no such craft shall be left unattended by day or night unless certain precautions have been taken against unauthorised use. Within the Defence Areas, all vessels holding passenger certificates or normally employed in carrying passengers, and all vessels, including rowing boats, normally used for private or pleasure purposes, must be either removed from the water, or beached, or rendered incapable of use, unless in possession of a valid naval permit for use. In steam vessels, the main throttle-valve cover plate and spindle, or other essential parts of the machinery, together with corresponding spare parts, must be removed from the vessel and stored in a safe place. In motor-propelled craft, the distributor arm, or a fuel-injection valve of a Diesel engine, or some other essential part, is to be similarly removed and stored. Some essential part of the steering gear is to be removed from sailing vessels, together with parts

of the windlass or sail-hoisting winches, if the sails are not portable by a single man; and smaller sailing vessels and rowing boats are to be immobilised by removing the oars, rowlocks, rudder, mast and sails, painters, etc., unless "an adequate and substantial-looking locking device" is applied to the mechanism, and the key taken away and locked in safe custody. The only exceptions permitted by the Order are craft employed by the Forces of the Crown, for police, fire or ambulance service, or as lifeboats of the Royal National Life-Boat Institution.

The Registration of Engineers.

Shortly before the outbreak of war the Ministry of Labour undertook the compilation of a register of persons possessing specialised technical qualifications, from which to supply the needs of Government departments and of industry for additional scientific, technical and professional staff. As a result, the corporate members of the leading engineering institutions were asked to provide data regarding their experience and, in spite of the somewhat rigid system of classification, gave this information in large numbers and to the best of their ability. It is now stated that there are, in all, some 22,000 names in the engineering categories on the register, and that only 800 of those on the books are not in employment. It may be assumed that of those employed a large proportion are already engaged on war work. The number available to assist in an intensification of effort cannot be large and this possibly explains the peremptory order issued by the Minister of Labour and National Service requiring all persons normally engaged in certain branches of the engineering profession to place their names upon the Central Register this week, under heavy penalties for non-compliance. Those affected are persons engaged in the engineering profession in a consultant, technical or supervisory capacity in design, construction, manufacture, operation or maintenance and who have had a regular engineering training in aeronautical, automobile, chemical, civil, electrical, gas or mechanical engineering. In addition, production engineers above the rank of foreman are included, as are engineering scientists holding an honorary degree and normally engaged on research work. There is no age limit. This registration is expected to add 30,000 names to the register.

The Scrap Aluminium Campaign.

The appeal by Lord Beaverbrook, Minister of Aircraft Production, to the women of Britain for aluminium "new and old, of every type and description" has had several interesting sequels. In the first place, it was answered with promptness and enthusiasm, with the result that a multiplicity of articles in various states of repair, but all useful for purposes of scrap, have flowed into the various depots. In the second place, those with deeper pockets than most have shown their patriotism, if not their economic sense, by purchasing aluminium articles in the retail shops and at once consigning them to the scrap heap. This behaviour naturally caused those less fortunately circumstanced to inquire why the Minister could not have taken this action himself. They received the immediate reply that the result would not have been worth the cost, that the stocks are low, and that, in any case, to start requisitioning would set an undesirable precedent. Finally, certain scrap merchants protested that they could not understand the appeal, as there were thousands of tons of scrap aluminium available in the country. The Minister replied that he did not want this aluminium; it consisted for the most part of inferior quality metal, which could not be used for the manufacture of aircraft. "We want rolled aluminium." A touch of light cynicism has been added to what, for some reason, has become a difficult situation. A civil engineer suggests that a large quantity of aluminium might be obtained by replacing overhead electrical mains, made of that metal, by steel of equivalent cross-section. There is also a shortage of steel, however, and there are reasons for supposing that Lord Beaverbrook, like the Prime Minister, thinks that the war will last a long time. More practical is the request that the aluminium rods, which have been picked up after air raids and are apparently used to hold incendiary bombs in their containers, should not be retained as souvenirs, but should be forwarded for disposal under the scrap scheme.

Scholarships for Farm Workers.

Whatever the distant future may bring, it is clear that for many years to come there will be a steady demand for an increased output from the farmlands of Great Britain. One method of assisting towards this end is by the development of mechanisation, which will require not only the machinery but also the personnel capable of utilising it effectively. A contribution towards the building up of such a personnel will be furnished by the scholarship scheme for farm workers, which has been submitted on behalf of Mr. Henry Ford and has received the support of the Minister of Agriculture. The plan covers the provision of forty scholarships, each of a value of about 175*l.* a year, this sum covering the cost of tuition and board-residence. Ten of the awards, known as Henry Ford Scholarships, will be for three years; ten, known as Edsel Ford Scholarships, for two years; and twenty, known as Perry Scholarships, for one year. The scheme is naturally intended for youths who wish to take up farming as a career. Training will be provided at the Henry Ford Institute of Agricultural Engineering at Boreham, near Chelmsford, practical work being carried out on the Fordson Estate Farms, which cover 4,000 acres, devoted to corn crops. The farms also have large market-gardening and fruit sections, with gas-storage installations, and extensive livestock. The courses are particularly designed to give instruction in all branches of mechanical farming. Youths desirous of being nominated to one of these scholarships should address inquiries to the Principal at the Henry Ford Institute of Agricultural Engineering.

LETTER TO THE EDITOR.

INCREASING WELDING OUTPUT.

To the Editor of Engineering.

Sir,—At the present time there are many thousands of arc-welding machines in use in Great Britain, on Government and armament contracts. Many letters have appeared in the technical Press from prominent industrialists, bemoaning the fact that machine tools are not working twenty-four hours a day. This contention undoubtedly applies also to welding machines, which are, of course, a form of machine tool. A case for much more serious concern at the present time, however, is the fact that, during the hours that arc-welding machines are used, they are almost invariably not being used to their full productive capacity.

This Foundation has been endowed to promote knowledge of welding and we would recommend every engineer who uses arc welding to give serious consideration to the following points:—(1) A welding operator seldom has his arc burning for more than four hours out of every eight. The operator spends the remaining four hours cleaning his welds, assembling the job to be welded, tacking and doing other work which could be done by unskilled labour. (2) Welding electrodes are seldom run at maximum currents. The rate of melting of the electrode increases as the welding current increases and welding currents can frequently be increased 10 per cent. or 20 per cent., and often can be increased 30 per cent. or 40 per cent., thereby giving a faster rate of welding. (3) Work is all too frequently welded with $\frac{5}{32}$-in. electrodes where a $\frac{7}{32}$-in. electrode can be used, a $\frac{7}{32}$-in. electrode is often used where a $\frac{9}{32}$-in. electrode can do the job. By using a larger electrode, a weld joint can be made very much more quickly because welding is a matter of depositing metal; it is sound economics and good engineering to use the largest electrode and the highest current possible on every job. (4) By the use of jigs, fixtures and manipulating devices for turning jobs being welded, the time the arc is in operation can be increased still further by turning work so that the operator is welding in the flat position. It is quicker, easier and safer for a welding operator to weld in the flat position, rather than in the vertical or overhead position.

We have no hesitation in stating that, if engineers who control welding operations were to give some consideration to the points mentioned above, the production of welded work could be increased by at least 10 per cent., and in many cases by 30 per cent. or 40 per cent. If only 10 per cent. increase in production were secured, this would mean that some thousands of welding machines would be released for productive work, instead of running idle, and a great number of skilled welding operators would be released.

Quite apart from the above question of increasing welding production, considerable quantities of steel can be saved by redesigning existing machinery and armaments, so that such machinery, etc., can be fabricated by welding. The use of welded fabrication inherently entails considerable saving in steel as compared with other methods of manufacture. It is quite common for machinery redesigned for fabrication from welded steel to show a saving of between 10 per cent. and 20 per cent. of the weight of steel required as compared with other methods of construction.

This Foundation is again offering 40,000*l.* as prize money for engineers who devote time and study to this question of the correct use of welding and obtaining the full benefits from welded fabrication. This prize money was endowed before the war started but, to-day, it is doubly important that engineers should give attention to these matters as part of the national effort.

Yours truly,

The James F. Lincoln Arc Welding Foundation.
R. Butler,
British Representative.

Welwyn Garden City,
Herts.
July 11, 1940.

THE LATE MR. G. E. WOLSTENHOLME.

On page 38, *ante*, we briefly recorded the death, on July 3, of Mr. G. E. Wolstenholme, of Sheffield, a local director of Messrs. Thos. Firth and John Brown, Limited, and a director of the Firth-Brearley Stainless Steel Syndicate, Limited. Mr. Wolstenholme had been intimately associated with the development of stainless steel, especially in its application in the cutlery industry, and collaborated in the production of the first knife made of this material, which was forged by hand, and is now preserved by the Cutlers' Company.

George Ethelbert Wolstenholme was born in Sheffield on May 12, 1875, and received his education in that city at All Saints' School and afterwards at the Sheffield Technical School. On leaving school in 1890, he was indentured as an apprentice in the engineering and boilermaking firm of Messrs. Hawksley, Wild and Company, remaining with them for a short period after the completion of his apprenticeship. He was then appointed works engineer to Messrs. John Holding and Company, engineers and forgemasters, Sheffield, for whom he carried out an extensive reorganisation of their plant. In November, 1897, however, he left them to become representative in Lancashire and Yorkshire for Messrs. William Parkin and Company, Limited, of the Crown Steel Works, Sheffield, and for the rest of his life was engaged on the commercial side of the steel industry. In 1906, he was appointed to represent Messrs. Thos. Firth and Sons, Limited, in the North Midlands, and thus, eventually, began his long association with stainless steel, of which he made a special study from 1914 onwards. In 1915, he has recorded, he gave the first lecture on this material, to the Manchester Federated Ironmongers' Association. In 1917, he visited the United States to demonstrate the possibilities of stainless steel and to superintend the commencement of its manufacture there at the works of the Firth-Sterling Company, the Bethlehem Steel Corporation, the Carpenter Steel Company, and the Washington Steel and Ordnance Company. On his return to Sheffield, he was made a director of the Firth-Brearley Stainless Company and manager of the stainless-steel department of Messrs. Thos Firth and Sons. Mr. Wolstenholme was elected a member of the Institution of Mechanical Engineers in 1922, and in 1934 and 1935 served on the Council as chairman of the Yorkshire Branch of the Institution.

THE LATE MR. A. E. ASH.

We regret to record the death of Mr. Alfred Ellis Ash, superintendent engineer of the Lancashire Shipping Company, Limited (Messrs. James Chambers and Company), Liverpool, which took place at Birkenhead on July 4, after a short illness. Mr. Ash, who was a native of Wakefield, was 72 years of age, and in his 55 years of active engineering had experience with an unusual variety of marine machinery, ranging from compound steam engines to supercharged Diesel engines and the pulverised-coal system of boiler firing fitted in the steamer Berwindlea.

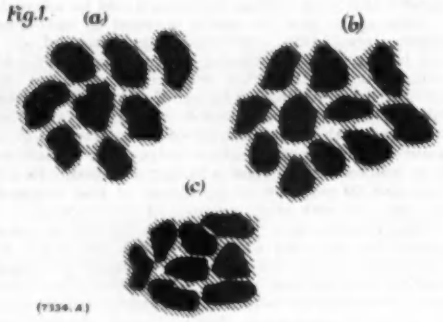
Mr. Ash received his general education at Royston School, Doncaster, at the Queen Elizabeth Grammar School in Wakefield, and at Bradford Engineering College; and, in 1885, entered as an apprentice the

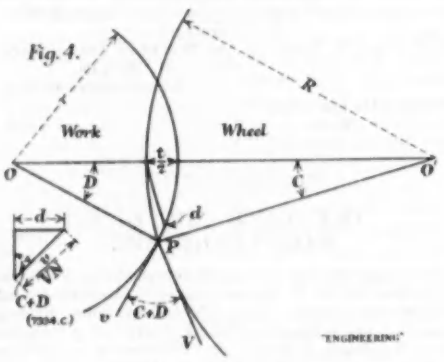
engine works of the Cunard Steam Ship Company at Bootle. On completion of four years' apprenticeship, he went to sea in the Mediterranean services of the Cunard Line, obtaining the first-class certificate of the Board of Trade at the early age of 23. He was then appointed to the liner Campania, under construction by the Fairfield Company at Govan, and made several voyages in her before being transferred to the sister ship, Lucania, on the completion of that vessel in September, 1893. Both ships at first showed a heavy coal consumption, and it was on Mr. Ash's suggestion, based on his experience in the forced-draught steamer Aleppo, that retarders were fitted in the tubes of their natural-draught cylindrical boilers, effecting a saving of some 50 tons of coal per day per ship.

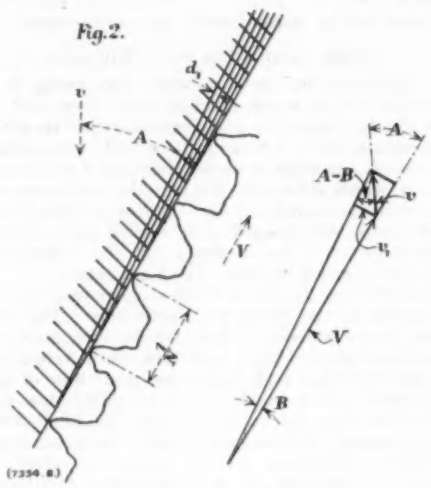
In 1897, Mr. Ash was appointed works manager for the Vauxhall Engineering Company, then occupying works in London and engaged in the manufacture of small marine engines and auxiliary machinery, including refrigerating plant. Eighteen months later he was made a director of the company and, in 1902, was closely concerned in the design and construction of the first Vauxhall motor-car. Two years later the company moved their works to Luton, where the motor-car side of the business was developed in conjunction with the other activities, but, in 1912, Mr. Ash left the firm to take up a partnership in Messrs. William Esplen and Sons, the Liverpool marine consultants. Among the ships with which he was associated through Messrs. Esplen and Sons was the Cairn Line steamer Cairnross, the first cargo vessel designed for propulsion by Parsons geared turbines, following the initial tests with the converted steamer Vespasian. For a time, during the war of 1914-18, he was attached to the Ministry of Shipping, but soon returned to Messrs. Esplen.

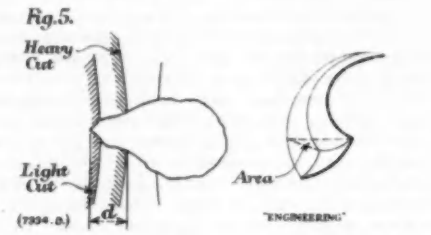
After the war, Mr. Ash turned his attention to marine internal-combustion engines, and was responsible for the engining and, subsequently, the supercharging of the motorship Raby Castle, the first Diesel-engined ship of the Lancashire Shipping Company and the first vessel to be fitted with the Büchi system of supercharging. This conversion was effected in 1927, and increased the power of the machinery by some 30 per cent., the maximum permitted by the dimensions of the original shafting. Two years later, Mr. Ash was responsible for another innovation in marine propulsion, when the collier Berwindlea was placed in service, fitted with the Clarke-Chapman system of pulverised-coal firing. During the war, he had had occasion to study the possibilities of the electric drive, and in the period between the end of the war and 1930, when he resigned his directorship in Messrs. Esplen and Sons, Limited, he was concerned with a number of turbo-electric installations, at a time when these were still considered rather a novelty in mercantile practice. In 1930, Mr. Ash left Messrs. Esplen, to become chief superintendent engineer of the Lancashire Shipping Company, the position which, as stated, he continued to hold until his death on July 4.

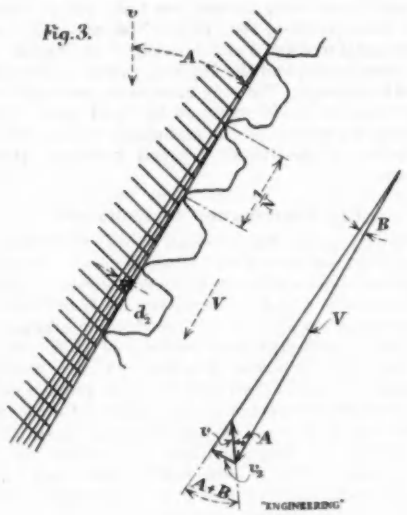
GRINDING-ACTION THEORIES.

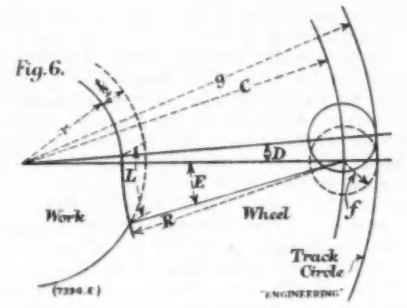












GRINDING-ACTION THEORIES.

(*Concluded from page* 18.)

WHILE the type of abrasive employed in a particular wheel is generally indicated by the trade name, and the grain size by numerals, the grade of hardness is usually indicated by a letter of the alphabet, with or without a numeral attached. Unfortunately, however, the systems adopted are purely arbitrary; thus, one make of hard wheel may be called E, the same grade being known as Q by another maker. The first-mentioned maker calls one of his soft wheels Q, while the second uses I for the same grade. The grade of an abrasive wheel does not depend on the kind of bonding used, but on the ratio of quantity of bond material to quantity of abrasive material. To illustrate this, Mr. Dall uses the conventional diagram shown in Fig. 1, on this page. In this illustration, sketch (*a*) represents a soft wheel, the thickness of the bond covering being noticeably less than that seen in the sketch (*b*) of a hard-wheel structure. In both these sketches the spacing of the abrasive grains is approximately the same; that is, the structure is the same, but in sketch (*c*) the grains are more closely spaced and the interstices very much smaller, resulting in a more dense structure. There is no definite method of structure designation, though tentative efforts are being made to ensure some method of structure indication by a symbol.

The kind of bond is frequently designated by a descriptive word. Many bond materials are in use to-day, the most common being vitrified shellac, silicate, resinoid and rubber. It would appear that the vitrified bond, *i.e.*, one made of fused clays, has the widest application. It has a wide hardness range and its porosity permits ready chip clearance, and, in consequence, cool cutting properties. It has, however, no elasticity. The shellac bond, made from shellac and other gums, has no interstices, and its high strength and elasticity enable it to be employed for very thin wheels. The range of grades is somewhat limited. The silicate bond, composed of clays fluxed by silicate of soda at low temperatures, has not a range of hardness equal to that of the vitrified bond in the harder grades. Rubber and resinoid are used when high wheel strength is necessary. It will be evident from what has been said above that the combination of grain sizes, grades, bonds and structures may be almost infinite in number. The field of grinding presents such a wide variety of operating conditions that each of the bonds mentioned above is more suitable for some classes of work than another. Nevertheless, a very precise selection of wheel is seldom necessary, since wheel action is very greatly affected by other conditions, such as wheel speed, work speed, traverse rates, work diameter, wheel diameter, grinding fluid and truing operation. After this rapid survey of grinding-wheel construction, Mr. Dall went on to discuss some theories of grinding action, referring first to a paper presented at the 1914 meeting of the British Association by Mr. James Guest, who, Mr. Dall stated, approached his theory from the standpoint of the geometrical consideration of the maximum chip thickness in a direction normal to the face of the chip. The theory is illustrated by Figs. 2 and 3, above. In these, the work is indicated by hatching and the abrasive grits are represented by the saw-tooth contour to the right of each figure. It will be noted that, in Fig. 2, the work is travelling in a direction opposite to that of the grinding wheel, the so-called "down-cut" grinding, while in Fig. 3 both work and wheel are travelling in the same direction, the so-called "up-cut" grinding. The peripheral velocity of the grinding wheel is denoted by V, and that of the work by v, but from the relative velocity diagrams on the right of both Figs. 2 and 3, the velocity of the work in a direction normal to its path will be seen to be v_1 and v_2, respectively. The pitch of the abrasive grits being $\frac{1}{N}$, then the time taken by one grit to reach a given point after the last one passes that point is $\frac{1}{N\,V}$. The chip thickness d = the normal velocity × the time; thus, $d = \frac{v_1}{N\,V}$ and $d_2 = \frac{v_2}{N\,V}$. But $v_1 = v \sin (A - B)$ and $v_2 = v \sin (A + B)$. Since the angle B is very small, it was neglected by Mr. Guest, so that $d = \frac{v \sin A}{N\,V}$.

The application of this principle to external cylindrical grinding is shown in Fig. 4, on this page. The expression for the time taken for succeeding grains to pass a given point remains as before and the velocity normal to the surface is $v_1 = v \sin (C + D)$, the final equation for the maximum thickness of the chip being $d = \frac{1}{N\,V} v \sin (C + D)$. Mr. Dall points out that this result can be obtained without resort to relative velocities and gives the various steps by which d is determined from the radii of the wheel and the work and the depth of the cut. Omitting these steps, however, it may be noted that the formula is then

$$d = \frac{v}{N\,V} \times \sqrt{\frac{R + r}{R\,r} \times t}.$$

GRINDING-ACTION THEORIES.

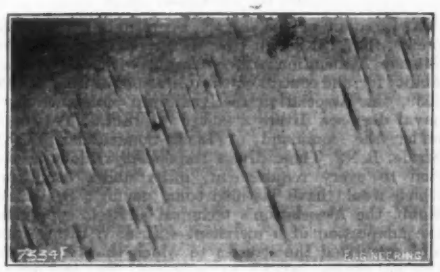


FIG. 7.

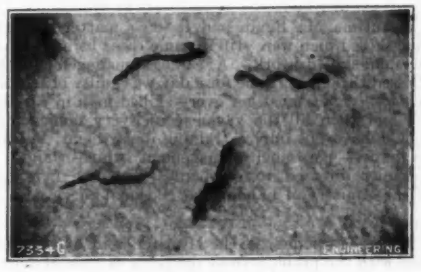


FIG. 8.

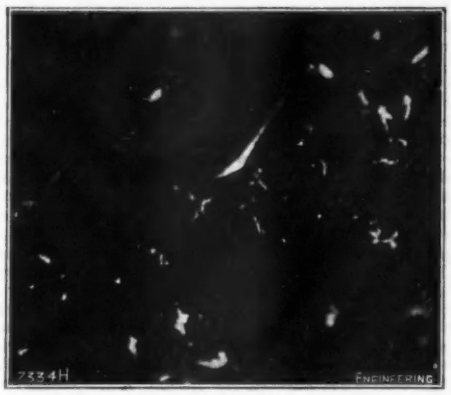


FIG. 9.

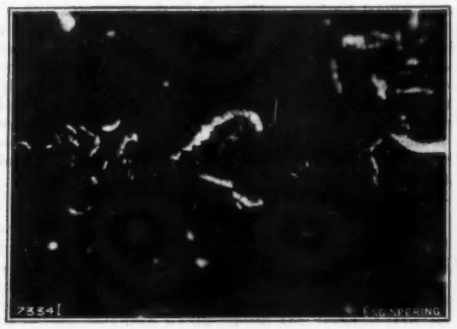


FIG. 10.

The quantities represented by R, r and t are indicated in Fig. 4, the depth of cut being $\frac{t}{2}$. A further hypothesis is that the maximum chip varies as the square of the maximum chip thickness when the grain is assumed to be roughly triangular in shape, as shown in Fig. 5, on the opposite page. This theory assumes that the force acting on the grain is proportional to d^2, and if the formula is written

$$d^2 = \frac{v^2}{N^2 V^2} \times \frac{r + R}{R\,r} \times t,$$

the tendency for the grains to break or dislodge will vary with the quantity on the right-hand side of the equation. For internal grinding this quantity becomes

$$\frac{v^2}{N^2 V^2} \times \frac{r - R}{R\,r} \times t.$$

The conclusion arrived at from this theory is, briefly, that the ratio of work velocity to wheel velocity, *i.e.*, $\frac{v}{V}$, has a large influence on wheel action and the depth of cut has a direct effect. For large wheels operating on small work, variations in wheel diameter have little influence, while those of work diameter have a large effect. With internal grinding, in which the wheel is small relatively to the work, the velocity ratio and the depth of cut affect wheel action in a similar manner to that in external grinding. The wheel-diameter variations will, however, have a greater effect than work-diameter variations in most cases.

In the same year as Mr. Guest's paper was read, Mr. George Alden presented a paper to the American Society of Mechanical Engineers. In this he proposed the formula

$$d = \frac{v}{N\,V} \sin (C + D),$$

which agrees with Mr. Guest's equation. Mr. Alden, however, tabulated the expression sin (C + D) in terms of wheel diameter, work diameter and depth of cut, the values thus tabulated agreeing very closely with values calculated by the Guest formula. Mr. Alden's theory assumes that wheel action, *i.e.*, force on grain, varies as the "grain depth of cut." Another theoretical treatment was put forward in 1937 in a paper by Mr. Roland V. Hutchinson presented to the Society of Automotive Engineers. Although the paper was largely concerned with grinding practice generally, *i.e.*, the consideration of work heating, coolant, dressing, and so forth, a mathematical derivation of an expression for average chip thickness was deduced. The geometrical construction is shown in Fig. 6, opposite. In this the wheel is regarded as rotating round the work at an angular speed equal to that of the work. To obtain this result geometrically, a rolling circle is placed on the wheel centre in contact with a track circle. The relation of the several circles is given by $\frac{f}{g} = \frac{n}{N} = \frac{D}{E}$, where n = speed of work in r.p.m., and N = speed of wheel in r.p.m. The length of chip is given as

$$L = \left(R \pm r\,\frac{n}{N}\right) \times \frac{R\,r}{R\,(R + r)}.$$

The plus sign in the first term of the right-hand side of the equation is for up-cut grinding and the minus sign is for down-cut grinding. The average chip thickness is obtained from the formula

$$d = \frac{r\,n}{R\,N \pm r\,n} \times \frac{t}{2}.$$

Since the angle D is the rotary movement of the wheel axis while a point on the wheel is moving through the distance L, the assumption is that the grits are pitched at distances L. To accommodate the formula to other grit spacings, such as used in Guest's and Alden's work, the angle D needs modification, but when this is done and the difference in the effect of down and up cutting is neglected, the resulting value of d is one-half that obtained by Guest for the maximum chip thickness. As d in the Hutchinson formula is the average chip thickness, the results of the two theories agree. Mr. Hutchinson's paper makes other contributions to the theories of grinding, including an equation for average chip thickness for surface grinding and modifications of the d formula, which is for plunge-cut grinding, to suit traverse grinding.

Still another geometrical analysis of grinding theory is that given by Dr. C. Krug in the issue of *Machinenbau* for September, 1925. His simplified formula for maximum chip thickness is given for plunge-cut external grinding as

$$d = \left(\frac{2\,R}{r} + 1\right) \times \frac{v}{V} \times \frac{r\,t}{2},$$

the notation being the same as for the formulæ given above. It would appear that Dr. Krug's formula was challenged; for one thing the grit spacing is taken as equal to one-half the arc of contact. Dr. Krug's reply to criticism was that chip thickness was not such an important factor as the plastic-flow conditions obtained when the chip is formed. In later papers, Dr. Krug analysed the structure of grinding wheels, the grains in this analysis being regarded as spherical in shape. It was argued that the grains can be packed in some manner between two extremes, *i.e.*, where the centres of the contacting grains are disposed on the corners of a cube or where the centres of the grains are placed on the corners of a tetrahedron, assumptions which show that the grits can occupy only from 52 per cent. to 56 per cent. of the total volume of the wheel. The remaining volume is occupied by bond material and clearance space for chip formation, and each grit is taken to have a coating of bond material only, as indicated in Fig. 1. With grits in such contact, Dr. Krug gives a method of estimating the force necessary to dislodge a grit for various thicknesses of coating at the point where bond and grits are continuous. The two conditions where the bond is in tension and under bending stresses are considered. The failure of the bond by shearing is not taken into account, though when a grit breaks out the five, or more, bonding contacts it may have, must fail by either bending, compression, tension or shearing, or probably by combinations of all four stresses, depending on the direction of the force in relation to the plane of the bond.

Mr. Dall's paper concludes with a short survey of the relation of grinding theory to practice. As the operation of grinding consists of thousands of individual events, few of which can be exactly similar to each other, it is impossible to arrive at as definite conclusions as with a single-point cutting tool. The theories really deal with the statistical average of these multitudinous events. Although the implications of the theories are borne out in practice in a qualitative way, experimental data are lacking to determine whether the theories are even roughly quantitative. The question of what constitutes a hard wheel and what a soft one has already been discussed, but it is a well-known fact that running conditions, as well as physical constitution, affect results. Thus, wheels appear to act as if they were harder than they really are when the wheel-surface speed is increased, and to appear softer when the work-surface speed is increased. In general, it is known that small work diameters require harder wheels for the same wheel action as that obtained on work of greater diameter. The theories can be used as guides in these questions until such time as definite proof of their actual truth is presented.

A characteristic of grinding as compared with other machining operations is that the cutting grains of the wheel occupy an indeterminate, and virtually infinite, number of positions, relative to the work surface, within the depth of cut. This results in different depths of "tool-mark" on the finished work, a condition which is clear from the microphotograph, Fig. 7, on this page. This shows a partly superfinished surface smooth to the touch. At first sight it might appear that the variations shown did not support the theories, but it should be remembered that many of the grains must be cutting in geometrical relation to the work as illustrated by the theories, and the statistical average is to be taken and not individual cuts. The theories take no cognisance of the effect of the plastic flow of the chip. Detailed studies of chip flow are, however, to be found in a paper by Mr. Hans Ernst and Mr. M. Martellotti (*Mechanical Engineering*, August, 1935) and in a paper by Mr. Ernst, read at Detroit in 1938. In the latter paper, all metal cutting chips are classified in three types. The second of these types, defined as the "continuous chip with continuously-escaping compressed layer adjacent to the tool face," would seem to be the most likely to occur in grinding because of the high speeds and shallow depths of cut. On the other hand, when it is considered that negative rake angles at the cutting points are inevitable, the third type, *i.e.*, the built-up edge type, would appear to be as probable. Mr. Ernst's paper showed conclusively that when these built-up edge conditions are encountered the result is a very ragged finish. The cutting grains being, however, very narrow and there being a probability of chip flow in a sideways direction, the whole aspect of rake angles is altered. The microphotograph, Fig. 8, above, shows grinding chips which apparently have characteristics of the second type. The microphotographs of other grinding chips, reproduced in Figs. 9 and 10, show other types. The large chip in Fig. 9 is noteworthy as its shape is approximately that of the geometrical configuration determined by the theories, as will be evident by comparing its contour with that of the theoretical chip in Fig. 4. The chip in the centre of Fig. 10 shows distinct segmentation which, with a ductile material, indicates the built-up edge type of chip.

It is evident that wheel action must be affected by such variables as the coolant, truing methods and so forth, since these variables affect the plastic flow of the chip. Thus, in addition to the working conditions recognised in the theories, other variables exist which modify wheel action and it would seem that considerable latitude exists in the choice of the proper wheel for a particular job. Broadly speaking, the choice is determined by whether proper wheel action is considered to be more important than quantity production in which the wheel is not used with its full efficiency.

GRAVING DOCK, SYDNEY HARBOUR.—The construction of a new graving dock for large ships at Sydney Harbour was commenced on July 8. It is expected that the work will take three years to complete.

LABOUR NOTES.

THE Ministry of Labour and National Service states that between May 20 and June 17 there was a reduction of 113,987 in the number of unemployed persons on the registers of employment exchanges in Great Britain. The total of 766,835 for June 17 was 582,744 fewer than the figure for June 12, 1939. The reduction in unemployment affected all areas and most industries. The industries showing the greatest reductions since the previous month included building and public works contracting, the distributive trades, coal mining, agriculture and horticulture, dock and harbour service, local government service, and the cotton industry. On the other hand, unemployment increased in the tailoring, dressmaking and millinery industries.

Of the 766,835 persons unemployed in Great Britain on June 17, 648,314 were wholly unemployed, 81,380 temporarily stopped, and 37,141 normally in casual employment. Of the wholly unemployed, 382,337 were men, 14,047 boys, 225,777 women and 26,153 girls, of the 81,380 temporarily stopped, 38,681 were men, 988 boys, 39,522 women and 2,189 girls, and of the 37,141 normally in casual employment 35,390 were men, 94 boys, 1,654 women and three girls. Between May 20 and June 17, the numbers of unemployed on the registers decreased by 10,356 in the London area, 5,605 in the Eastern area, 5,038 in the Southern area, 5,356 in the South-Western area, 7,265 in the Midlands, 5,520 in the North Midlands, 9,062 in the North Eastern area, 31,114 in the North-Western area, 11,046 in the Northern area, 11,763 in Scotland, and 11,862 in Wales.

In June, the home branch membership of the Amalgamated Engineering Union increased from 413,790 to 418,304, and the Colonial branch membership from 37,782 to 37,828. The number of members in receipt of sick benefit decreased from 3,912 to 3,686, and the number on superannuation benefit from 13,713 to 13,636. The number in receipt of donation benefit decreased from 537 to 447, and the total number of unemployed members from 2,765 to 2,608.

The *Monthly Trade Report* of the United Pattern-makers' Association states that, in June, the number of unemployed members increased from 51 to 58. The number of members in receipt of sick benefit was 220—a decrease of 23 as compared with the previous month—and the number of superannuated members decreased from 671 to 667. There was a net increase of 53 in the membership, which is now 12,443.

Mr. Tanner, the president, reports, in the July issue of the Amalgamated Engineering Union's *Journal*, that a meeting of the full National Railway Shopmen's Council was held in London on June 17 to receive the reply of the railway companies to the application of the trade union side for an increase of 10*s.* a week. After a full discussion, he says, the following settlement was arrived at:—"That the existing war bonus of adult male staff be increased by 3*s.* per week and that increases of 1*s.* 3*d.* per week be granted to boys and apprentices over 18 and under 21 years of age, and 8*d.* per week to those under 18 years of age."

At the end of May, 1,515 members of the Boilermakers' and Iron and Steel Shipbuilders' Society were "signing the books," as compared with 1,753 at the end of April. During May, the number of members on superannuation benefit decreased from 3,486 to 3,429, and the number on sick benefit from 1,125 to 918. The expenses in April amounted to 3,903*l.* 0*s.* 6*d.*; in May—which included five weeks' outlays—they were 4,517*l.* 11*s.* 1*d.* There was a net increase of 1,041 in the membership in May.

An application by the union side of the Shipbuilding Trade Joint Council for Government Departments for a wages advance of 8*s.* a week for fitters, turners, coppersmiths and blacksmiths employed in H.M. Dockyards and other Admiralty establishments at home has been rejected by the Industrial Court.

Speaking at a luncheon in London last week, Mr. Bevin, Minister of Labour and National Service, appealed to women who have never been in a factory to come forward for part-time work in order that women already working may have adequate rest. He emphasised the fact, however, that the intake of fresh labour must depend on the making of the fullest use of skilled men and of the training facilities available. The Government had extended the training centres and intensified the training. But the greatest scope of all for training, he went on to say, lay in the works, and he called on managements and labour to co-operate in developing that training. "If they will do their parts," he declared, "in an organised and energetic way, we can have the full staff to complete our programme in a very short time."

Meantime, Mr. Bevin said, it was a matter for regret that skilled men were still in some cases being retained on semi-skilled work. A careless management that allowed that to continue for a day was guilty of criminal neglect. They must get every skilled man in a skilled job and then fill the vacancies. Every management should have not only a training department, but also an expert personnel management which should be specially directed to co-operate with the inspectors of the Ministry of Labour and National Service.

It was not sufficient, the Minister went on to say, to deal with the problem from the point of view of defence only. The services had to be fully equipped for greater tasks than that; that was only the first round. Equipment must be, if anything, in excess of the marvellous courage of the men in the fighting services. It must err on the side of over-supply rather than that of under-supply. At the same time, while we were carrying out this task of equipment we must reduce or cut out every unessential operation, and yet keep the life of the nation going and maintain a good deal of export trade. He paid tributes to the fine response of the workers to his appeals and to the co-operation of works' managers, the Trades Union Congress and the British Employers' Confederation.

The General Council of the Trades Union Congress has made a loan of 10,000*l.* to the Government free of interest, and has given 1,000*l.* to provide four mobile canteens for the use of troops in this country. Making these announcements, Sir Walter Citrine said the General Council was urging all its affiliated unions to grant interest-free loans to the Government. It would be the desire of the movement to place the maximum of its resources at the disposal of the country in this critical hour of need.

The Ministry of Labour and National Service has appealed to employers to release chauffeurs and chauffeur-mechanics for war work in armament factories. It is believed that men of these types would readily adapt themselves to such work, especially if they took a course in a Government training centre or in a works. Employers should, it is suggested, discuss the matter with their chauffeurs, and men who are willing and can be released should register at an employment exchange, where they will be considered either for immediate employment, if suitable, or for training. They should not leave their present jobs until placed elsewhere.

Plans and suggestions for the still greater acceleration of the pace of the arms' speed-up were discussed at a conference at the Ministry of Supply last week between the Minister (Mr. Herbert Morrison) and managing directors and other leading members of firms working on war contracts. Among matters touched upon were rationalisation of production of certain essential items, simplification of procedure in ordering, new methods for ensuring the discovery and full use of spare capacity, employment of substitute materials, closer consultation between manufacturers and the Ministry in working out new specifications, and further relaxation of inspection. Mr. Morrison undertook to have every new suggestion examined.

The text of the agreement between the Engineering Allied Employers' National Federation and the Amalgamated Engineering Union on the subject of the wages to be paid to skilled men transferred from production to tool-room work, is reproduced in the July issue of the A.E.U. *Journal*. It is as follows:—"For the purpose of ensuring during war-time emergency, the necessary complement of men and production from tool rooms as distinct from manufacturing establishments, it is provided that the minimum earnings of skilled operators in the tool room, or skilled men who are transferred from production to tool-making work, shall be not less than the average earnings of the skilled production workers in the same establishment for the same number of comparable hours worked. In the case of men who are receiving an individual merit rate, such merit rate shall be maintained."

The executive council of the Amalgamated Engineering Union have agreed with the Iron and Steel Trades Employers' Association that having regard to the national emergency and the appeal of the Government, normal holidays be suspended. Holiday payments will be made at the normal time and additional payments for work done during the normal holiday week will be made where such payments are provided for in national or local agreements.

THE SALVAGE OF H.M.S. "THETIS".*

By G. R. CRITCHLEY, M.A.

AN account of the salvage operations requires the prefix that, although the Liverpool and Glasgow Salvage Association was entrusted with sole responsibility for, and control of, the operations as from June 9, 1939, the Association received vital assistance from naval deep-sea divers attached to H.M.S. Tedworth, under the command of Lieut.-Commander W. J. Stride, R.N. These divers responded without hesitation to every requirement, often under conditions which would have justified some demur. Dr. A. M. Robb, the Association's technical adviser, supervised the adaptation of a merchant ship as a lifting unit, and calculated the stresses to which that vessel and the submarine would be subjected by the lifting operations. His calculations are used in the narrative.

The submarine was sunk in position 348 deg. 15 miles from Great Orme's Head Light, in a depth of 25 fathoms at low water spring tides. The average tidal range was found to be 22 ft., with a surface velocity reaching 4 knots. At times there was no period of slack water, and at best the slack-water period did not exceed 30 minutes. The position was exposed from all quarters, and the worst sea conditions could be expected with prevailing south-west through west to north-west winds. The Association's long experience supported the view that the ordinary type of dumb lifting camel used by harbour authorities for raising wrecks from navigable channels would be useless under these conditions, because even in moderately bad weather they would be completely unmanageable. This was demonstrated at the time of the Mersey Docks and Harbour Board's unsuccessful attempt on June 7. Under favourable conditions, the camels were pinned down at 9.30 p.m., but, with the incoming tide, conditions quickly deteriorated to moderate breeze and moderate swell, in which the camels rolled and laboured heavily, and about midnight the after-wires successively parted and the forward wires had to be hurriedly slipped. The depth of water and the tidal velocity were both adverse to the work of divers. At the minimum depth of 25 fathoms, which involved divers working at a pressure of 66 lb. per square inch, sustained manual effort was impossible, and the tidal velocity would prevent divers descending, except during slack water. Divers cannot keep position in normal working depths, that is up to 80 ft., in a current of more than 2 knots. In shallower water, and dealing with a merchant ship, wires can generally be swept under the wreck. That method was useless, because there could be no certainty concerning the positions of the wires; the ballast keel of the submarine would obstruct a passage of wires along the bottom; there would be fouling of hydroplanes; and cutting of the wires owing to the form of the structure if they were slung at particular positions under the fore-end of the submarine. The divers were therefore essential to pass reeving wires and to check the positions of the lifting wires.

The decision to reject dumb lifting camels for use in this case led to the adaptation of a merchant ship as a lifting unit. The considerations affecting the choice of such a ship were that she should be of approximately equal length to the submarine; that her deck plan should permit us to arrange eight lifting beams athwartships, spaced so as to be approximately vertical to selected positions along the length of the submarine, so that as the submarine was carried into shallower water, and brought up closer to the lifting unit, none of the wires should assume a very acute angle; and that the four forward and four after beams should be capable of symmetrical distribution before and abaft the centre of buoyancy of the lifting unit, so that she would not materially alter trim under the load. She should have generous ballast tanks so as to preserve stability with the heavy beams and other salvage gear placed on deck; she should not fine too rapidly at the ends, because the method would necessitate the transfer of the load from the decks to the tank tops through struts erected in the holds; and the greatest possible breadth at the ends was desirable for a wide distribution over the tank tops, because a narrow tank top would have involved excessive concentration of the load and an excessive slope of the struts. It was also necessary that the lifting unit should have space for the fitting of sleeping and feeding accommodation for a salvage party of about fifty men, in addition to the navigating personnel, so that the whole unit could be self-contained.

The plans of numerous vessels were obtained and the Zelo was chosen. She was 308 ft. long and 43 ft. beam, in contrast with the submarine's length of 275 ft. overall and 26 ft. 6 in. beam overall. Her deadweight carrying capacity was 3,350 tons, inclusive of 450 tons

* Paper presented to the Institution of Naval Architects. Abridged.

of bunkers, and the submerged weight of the submarine was said to be about 1,000 tons. She had a total water-ballast capacity of 1,036 tons, of which 73 tons was taken in ballast tanks on the port and starboard sides of the tunnel. Fresh water for boiler-feed and drinking could be carried in two tanks in the engine room. Her tons-per-inch immersion between the ballast condition and the contemplated loaded condition was 35, and thus only a small part of the rise of tide was lost by the mean sinkage of the lifting unit.

It was considered desirable to use eight slings, each of 9-in. wire. The nominal breaking strain of wire of that size, which is constructed of six strands, each of 61 wires of best quality galvanised steel laid clockwise around a hemp core, is about 240 tons. Twelve wires, each 120 fathoms long, four to be held in reserve in case of breakage, were constructed and delivered by the Rutherglen Works of Messrs. British Ropes, Limited, in the record time of twelve days, and were tested to a breaking strain of 265 tons. That gave a factor of safety of four in the wires, assuming uniform loading, and may seem, *prima facie*, to be the reverse of normal practice, which aims at a greater margin of safety in the means of attachment than in the wires themselves; but it was assumed that ten lifts would be required to take the submarine into shoal water, and that there would be considerable chafing and consequent weakening of the wires.

The athwartship lifting beams on the deck of the Zelo were each constructed of four square pitchpine logs, the ends of which overhung the deck on each side 3 ft., and were formed into bobbins by means of beech segments laid over the outer surfaces of three of the logs, and by greenheart segments laid over the outer surfaces of the fourth log in an order which met the condition that the wires would be taken round the bobbins and would be belayed in the clockwise direction, coming up on the after-sides of the beams on the starboard side, and on the fore-sides of the beams on the port side. This clockwise winding of the wires conformed with the clockwise lay of the strands. The greenheart segment formed the top quarter-circle of the bobbin, with which the lifting wire made contact as it entered upon its first turn, and the soft beech segments were used to permit the wires to bite into them to increase frictional resistance to slipping.

Figs. 1, 2 and 3, on page 50, show details of the lifting beams and under-deck stiffening. It was considered desirable to support the beams on grillages with soft wood packing, such as is used in the construction of fore poppets, in an endeavour to distribute the load over the portions of deck between bulwarks and hatch coamings on the lifting vessel. The effect of the packing and the consequent indeterminate distribution of support was that the exact magnitude of the bending moment was not known. Moreover, it was considered necessary to reinforce the beams by fitting wire ties secured around cross-beams on the inner bottom of the ship. As the tension in the wires was not known, another indeterminate element was introduced. It was possible, however, to determine the limiting values of the bending moment. In the result, there was a fairly wide range of possible bending moment, but not a very wide range of possible beams to resist this moment. Thirty-two pitchpine logs, ranging from 12 in. square to 16 in. square, were arranged in the groups of four, with the larger logs placed nearer amidships in the lifting vessel, because it was expected that the loads there would be greater. With such an arrangement the stresses due to bending moment were not large.

Consideration of the resistance to twisting moment was more difficult. On an ordinary approximation to the strength of the rectangular section, and on the assumption that in each beam the four logs acted independently, the stresses were high. A cruciform ¾-in. steel plate was therefore interposed between the four grouped logs at each end of each beam, extending completely over the region of support, and the ends of the beams were bound together when the bobbins were formed. Further, in way of the hatch coamings, they were buttressed by fore and aft logs fitted between the beams, and from the end beams down to supports on the deck. It was not possible to arrange similar buttresses near to the outboard ends of the beams because this would have impinged upon the working space. Fig. 4, on page 50, shows the arrangement of the beams on the fore deck of the lifting vessel, and Fig. 5, on the same page, shows the under-deck supports and stiffening. The disposition of the stiffening was governed in part by the desire to tie the beams at the mid-lengths, which explains the arrangement of cross-beams and diagonal struts.

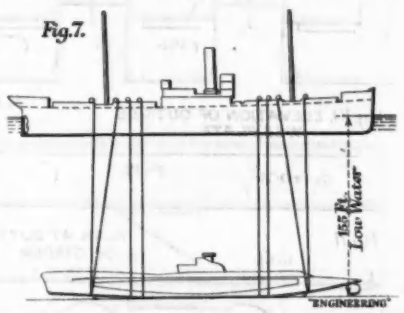
The Association's experience was that, with three complete turns of a 9-in. wire round each bobbin, the free end of the wire could be held by a light tackle with a pull of less than one ton. The method of "pinning down" at low water was to heave up the 9-in. wire on each side of the lifting craft with the ship's derricks and winches; when the wires had been hove to maximum tautness, they were secured at a point immediately below the bobbins by clamps, and the free ends worked round the bobbins.

It became necessary to consider the strength of the hull of the submarine to withstand the stresses imposed by the contemplated method of positioning the wires. The salvage officer in charge at that time desired approval of the positioning of four wires just forward of the fore end of the ballast keel, and four wires abaft the keel, with a view to eliminating the difficulty of placing wires under the keel, avoiding the risk of cutting them by the sharp edges of the keel, and avoiding damage by the wires to the external ballast tanks. It was known that, by this method, the slings would be about 188 ft. apart.

Dr. Robb advised that, assuming that the whole weight of 1,000 tons was uniformly distributed over this length of 188 ft., the bending moment would be 23,500 tons ft.; and, alternatively, that, assuming that 90 per cent. of the weight was thus uniformly distributed, and the remaining 10 per cent. acted at 20 ft. beyond each sling, there would be a bending moment of 20,150 tons ft. On the first assumption, the tensile stress on the material of the pressure hull would be about 15·3 tons per square inch, and on the second, about 13·1 tons per square inch; and, in his view, these stress figures were not so high as to render the proposed method inadmissible.

A concentration of four wires upon a small area in way of the spaces which were vital for the purpose of evidence might have cut through the pressure hull, or caused disturbance, which would have defeated one of the objects for which the salvage operations were

Fig. 7.



undertaken, and accordingly an interview was sought with Sir Stanley Goodall, the Director of Naval Construction. He concurred in Dr. Robb's estimated stresses on the assumption that the submarine was completely flooded fore and aft, disregarding possible airlocks. If, however, one or more of the main compartments remained watertight, the pressure hull in that neighbourhood would be subjected to stresses due to the depth of water which would perhaps be as much as 8 tons per square inch, and in that case the total stress would be of the order of 17 tons to 20 tons per square inch, and might have serious effect. The result of the discussion was that we agreed to place two lifting wires under the keel forward of the conning tower and two under the keel abaft the conning tower, so that the positioning of the eight wires would be as shown in Fig. 7, on this page.

The precise direction in which the submarine was heading was found to be S. 80 E., with a list of 15 deg. to 20 deg. to starboard. The ground was found to be blue clay, with a mound on the port bow, and a hole about 8 ft. deep on the starboard bow. The keel at the fore end was slightly off the ground, but the stern had settled into the bottom up to the level of the starboard propeller boss.

The Zelo was ready to sail on June 28, but, owing to a southerly gale, did not sail until the evening of June 30. Conditions were still unsettled, and there was a critical interim stage between the time when she could be placed over the wreck and heavy ground moorings laid out from the four quarters as well as from ahead and astern. It was not until July 4 that she could be moored in position. Weather prevented divers descending until the morning of July 6, when reeving wires were passed under the submarine's bow immediately forward of the keel. On that night, the weather rapidly deteriorated and became a whole south-westerly gale with heavy sea, and in the early hours of July 7, the Zelo's starboard moorings dragged and she broadsided to the gale, carrying away two heavy bollards and fracturing the bases of other bollards on the forecastle and poop. As there was no sign of improvement of weather conditions, she was instructed to return to Messrs. Cammell Laird's basin.

As large-scale charts showed unevenness of the sea bed between the position of the casualty and the east side of Anglesey, to which it was intended to carry the submarine, and the presence of wrecks in these waters was also known, a course was plotted which would give the clearest possible path during the movement inshore. The Controller of the Navy was good enough to place at our disposal the services of H.M. survey ship Gleaner for this purpose. The Gleaner also ascertained that sub-surface tidal currents ran in a direction sometimes as much as 60 deg. divergent from the surface current.

While new bollards were being fitted to the Zelo, consideration was given to improving the heavy ground moorings in order to avert a recurrence of the dragging which had occurred during the south-westerly gale. Our practice of rigging ground moorings to heave off a ship which is aground is to shackle the heaving wires to manilla purchases which are laid along the deck of the stranded vessel. These act as springs which absorb shocks coming upon the moorings in bad weather, in addition to their function as heaving appliances. That device was impracticable in the case of Zelo, because the purchases laid along her deck would have obstructed the manipulation of the lifting wires. It was eventually decided to interpose not less than 30 fathoms of stud-link cable between each of the main salvage anchors and wires, to act as springs in case of bad weather. The new plan was to adopt the chain-cable spring moorings as permanent for the original position and to provide a complete set of supplementary moorings to be laid in any new position to hold Zelo until the chain-cable moorings could be lifted and relaid. A plan of the revised system of moorings is given in Fig. 8, on page 58, showing the chain moorings in continuous lines, and the supplementary moorings in dotted lines. The salvage steamer Ranger remained at the case lifting the moorings which had dragged. By continuous day and night work, Zelo was again made ready, and proceeded to the case shortly before midnight on July 11, but a forecast of westerly winds delayed mooring, and on July 13 there was a strong south-west wind with no prospects of operations being resumed. On July 14, Zelo sheltered in Moelfre Bay. On July 15, there were strong northerly winds. Weather moderated during the night, and divers were able to descend during the low water slack period at 5 a.m. on July 16. There was, however, considerable trouble by reeving wires becoming foul owing to the strong currents, and it was not until the evening of July 18 that one lifting wire was placed in position under the propeller shafts of the submarine. At midnight another was placed in position under the fore end of the keel, and at slack water on the morning of July 19 another lifting wire was rove at the selected position forward of the keel. By the afternoon of July 20, six wires had been placed, and it then became necessary to lift the stern of the submarine in order to place the remaining two lifting wires in position.

On the early morning tide of July 21, the stern of the submarine was lifted smoothly off the ground and one 9-in. wire was placed well below the keel; but the reeving wire for heaving into position the remaining lifting wire fouled, and at 3.5 a.m. a wireless message was received from the salvage officer reading:—"Will you concur our lifting with one wire below keel aft and three wires between keel and propellers?" Approval was given on the understanding that the three aftermost wires were placed, one under the propeller shafts adjacent to the stern tube, one forward of the embrasure plates, and one at the point of junction of the after end of the keel with the hull.

On the midnight tide of July 21, all the wires were hove taut, and a test was carried out for the purpose of determining that each wire could be hove straight through from one side of the submarine to the other. This test was to ensure that if, during the course of a complete bodily lift, any wire or series of wires carried away, they would reeve freely under the submarine and eliminate the risk of an unbalanced load coming upon one side only of the lifting craft. This test proved satisfactory. It was decided to make the first complete lift on the early morning tide of July 22, and at 7.15 p.m. on July 21 a start was made to take in slack wires; low water being at 9.40 p.m. Weather conditions at that time were ideal. At 1.30 a.m. on July 22, when, if all was well, the submarine should have been moving inshore, the author transmitted an inquiry to the Admiralty Liaison Officer at the case and received the following reply:—"Regret to report there has been no victory stop In spite of excellent weather conditions severe strain possibly owing to light stern and heavy bows of Thetis caused No. 7 and No. 6 beams to collapse in that sequence stop."

The following facts emerged: What was thought to be a perfect pin was made at low water, and all the wires were examined so that the load, as far as could be judged, was being evenly distributed over all the wires. Some adjustment was made to Nos. 1, 6, and 7 wires, numbering in order from the forward end of Zelo, and these wires were rendered up to approximately 18 in., to secure uniform loading. At that stage, about an hour after low water, all the wires were held. For some reason the load on No. 5 wire did not increase at the same rate as the load on Nos. 6 and 7 wires, and

the load on No. 8 wire became released altogether. Our officer did not know what load he had on No. 5 wire, but it seemed to have a fair load, although it did not show signs of serious straining as did Nos. 6 and 7 wires. As the tide rose, Nos. 6 and 7 beams began to show signs of twisting, and the fibres of the beams began to yield.

Under those conditions the tackles holding the ends of the wires were continuously released by hand, and the wires rendered around the drum ends of the baulks in a series of very severe jerks. A stage was reached where it was not safe for men to try any further regulation of the load, and at that stage the tackles holding the ends of the wires carried away. Our officer was satisfied that the stern of the submarine was raised a considerable height from the ground, and that the bow was raised intermittently from the bottom, and its full weight was applied to baulks Nos. 6 and 7 with the result that the wires rendered until the bow again took the ground. These conditions were accompanied by the surging of the submarine ahead caused by the tide, and with each surge the bow made contact with the bottom, and during the momentary bearing of the full weight of the bow on the bottom and the resultant release of the load upon the wires, these wires slid in jerks up the inclined keel to a position farther aft of the bow. Increase of the mean draught of Zelo showed that she was carrying a load of between 900 tons and 975 tons, which subsequently proved to be the total submerged weight of the submarine, and in our officer's opinion, about 75 per cent. of that load was borne by baulks Nos. 6 and 7, and 25 per cent. by baulks Nos. 1, 2, 3 and 4. The uneven loading of the after baulks on the Zelo was attributed to No. 8 wire being fouled, probably by a forward hydroplane. As the load increased, it freed itself, and, in fact, streamed away towards the stern of the Zelo, with the consequence that it exercised no restraint upon the tipping of the submarine at the bow. It was supposed that No. 5 wire either fouled debris or was lying with a slight kink under the bottom, and when it became slack it was able to slip along the inclined keel towards the conning tower without taking any load.

As no means existed of retaining the lifting wires in their allotted positions, having regard to the strength of the tides and the impossibility of sending divers down to check the positions of the wires in the limited time available, it was decided to consider replacing the lifting baulks with steel girders capable of withstanding concentrated loading. A conference called by the Controller of the Navy was held on July 27, and it was agreed that operations should be continued with the proposed steel girders.

A request was made that the Admiralty should provide a mooring vessel to assist the Ranger in raising and relaying all the heavy ground moorings to keep pace with the Zelo carrying the submarine inshore. In the course of a few days a design of steel beams with built-in bollards was produced, but the time for construction and fitting was estimated at six weeks. As that would have meant that operations would not have been resumed until the middle of September, representations were made for a simplification of the design, and detailed amendments were made; but Messrs. Cammell Laird and Company's yard was to be closed from August 5 to August 12. After a personal appeal to the managing director of Messrs. Cammell Laird and Company, holiday leave for the men required was suspended, and by continuous day and night work the Zelo was refitted and again proceeded to the case on the morning of August 24. This was a magnificent performance, and in the result the saving of time was probably vital to the success of the operations, because, in fact, lifting operations were completed by September 3, and the weather broke on September 10.

Figs. 9 to 12, illustrate the steel beams with built-in bollards and a cast-steel bolster at each end, constructed with leads to the bollards to take the load over the deck edges of the lifting craft. It was decided that the bollards should be capable of withstanding a load greater than the breaking load of the 9-in. wires, and that they should be arranged so as to leave adequate working space in the centre of the deck. The bollards were constructed from 1¼-in. plates, and plates of this thickness rolled to an outside diameter of 36 in. would be subject to a stress of rather more than 3 tons per square inch under the combination of the calculated bending and twisting moments of 2,715 in.-tons and 3,413 in.-tons, respectively.

The requirement that the bollards should be incorporated in the beams suggested the provision of a bottom plate as well as a normal base plate, the distance between the two being the depth of the lifting beam. As it was decided that 30 in. would be an adequate depth for the beam, the bollards were made 5 ft. long. They were reinforced internally to resist the calculated crushing loads. The width of the base plate was determined by the need for the provision of adequate scarfs for the outer webs of the cross-beam, and the extensions of the base-plate at the centre line of the bollard were arranged to provide attachments for a central web of the cross beam. A completed bollard was tested at Lloyd's Proving House at Netherton to a pull of 180 tons. There were two figures of eight on the bollard with one end of the wire secured to the standing end of the testing machine and the other end secured to the travelling end. There was no sign of disturbance of either riveting or welding on examination of the bollard after the test.

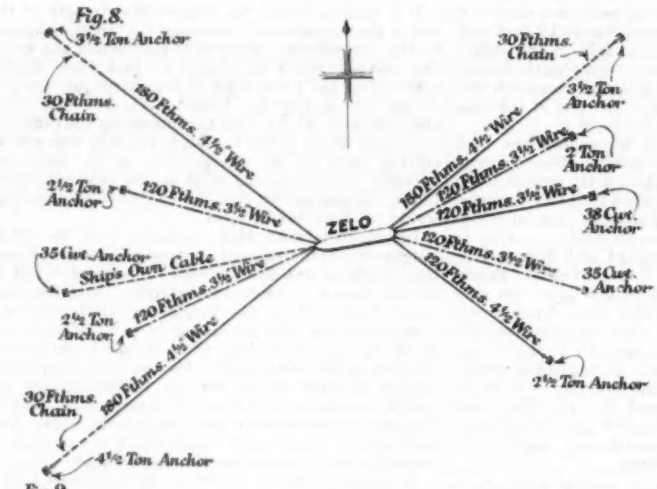
The beam was adequately strong to resist the bending moment imposed by the vertical loads on the wires, and the bending moments in the horizontal plane set up by the wires leading off the centre to the circumferences of the outer pins were resisted by struts fitted between the bollards and from the end bollards down to the deck. These struts served also as anchorages for the beams in the event of the submarine when slung touching the ground while the lifting vessel still had ahead motion, in which event there would be a tendency for the lifting beams to be dragged aft. As a precaution against the submarine acting as an anchor while the lifting ship was being drifted to leeward, the brackets shown in the illustrations were arranged below the bollards.

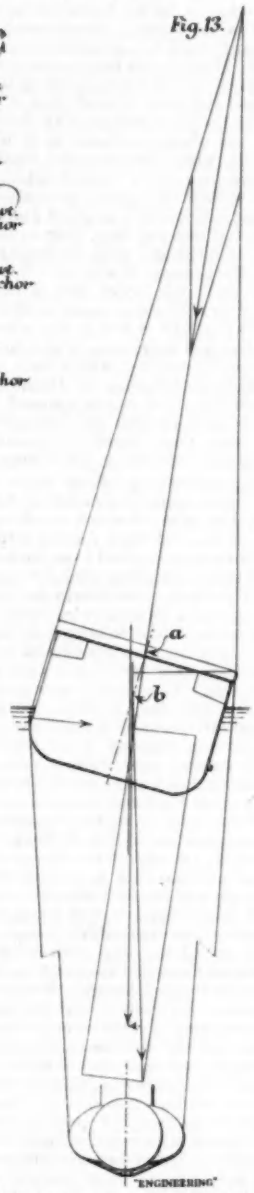
It had been estimated that under the original conditions the lifting ship had a fairly generous metacentric height, even with a load of about 1,000 tons suspended from the beams on the upper deck. The steel beams, however, were much heavier than the timber beams, and it was considered proper to carry out an inclining experiment shortly before the ship sailed. This showed that, with the load slung from the beams, there would be a small positive metacentric height.

Fig. 13, on this page, is a diagrammatic representation of the lifting vessel inclined with the submarine suspended below, *a* and *b* being, respectively, the virtual centres of gravity of the load when the vessel is upright and inclined. This shows that, although at a small angle the load would be freely suspended, and therefore would act as if it were concentrated at the ends of the beams, one wire would soon be constrained at the bilge. The effect of this constraint is shown by the diagram as resulting in a lowering of the effective centre of gravity of the load. The diagram is based, however, on the assumption that the wires can render freely under the hull of the submarine. Experience in other cases indicates that rendering does not occur, and that, therefore, submarine and lifting ship virtually behave as a single unit, with the two portions rigidly connected. The main consideration is that both the diagram and the facts of experience show that the stability consideration does not present a serious problem; in fact, when the submarine was slung off the bottom, the Zelo was perfectly stable. Timber baulks were fitted above the turn of the bilge along each side of the lifting vessel, to prevent indentation of the ship's side by the wires in the event of heeling under the load.

When the Zelo returned to the scene of operations on August 24, weather conditions were ideal, and by August 26 she was moored over the wreck, and all ground moorings and the lifting wires Nos. 1, 2, 7, and 8, which had been left in position after the unsuccessful attempt on July 27, were picked up. There was still, however, the persistent trouble of wires becoming foul owing to the tides, but by the morning of August 28 all lifting wires were in position, and Zelo was pinned down at low water, 6.30 a.m. The submarine was lifted on the morning tide, and the first move inshore

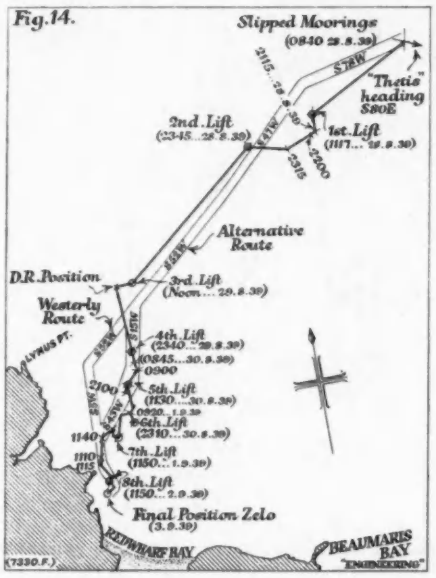
THE SALVAGE OF H.M.S. "THETIS."





THE SALVAGE OF H.M.S. "THETIS."

Fig. 14.



was successfully made. Further lifts were made on each succeeding tide until six lifts had been completed by 11.10 p.m. on August 30, when the submarine had been carried into 78 ft. at low water and was in a position N. 40 deg. E. true, 2 miles from Moelfre Island. In that position it was necessary to remove the forward periscope to prevent fouling the bottom of the lifting craft; the after periscope having already been bent nearly horizontal at some earlier stage.

Two further full tidal lifts were made, and finally a half-tide lift, which carried the submarine into a position S. 33 E. true, eight cables from Moelfre Island, where she lay in 37 ft. of water at low water; that is to say, her conning-tower hatch was about 9 ft. 6 in., and her bridge casing about 3 ft. 6 in., below water. Fig. 14, on this page, shows the successive positions after each lift, and the course taken. The course plotted by H.M.S. Gleaner is shown by parallel lines, and it will be seen that it was impossible to follow exactly the marked course because of drift caused by the tides.

After the second lift, and during the second movement inshore, the submarine became pinned against a sandbank and remained for three hours, but cleared the bank with the continuing rise of ride. The situation was an anxious one, with Zelo broadside to the strong tide, but the tugs were able to hold on. Grounding of the submarine in the course of the movements inshore must be regarded as merely incidental to the operations. A common misconception is that a move inshore is not begun until the sunken craft has been lifted a substantial distance from the bottom, or, in other words, until a late stage of the flood tide, but in fact the move begins as soon as the sunken craft is off the bottom, and then takes the form of a slow creep inshore on to higher ground until, with the turn of the tide to the ebb, the sunken craft settles again on the bottom and the lifting wires slacken. If the bottom shelves very gradually a greater distance can be covered in one tide than if the bottom shelves more steeply, and if the bottom is irregular so that a bank must be traversed, a movement may be short while the bank is being negotiated, but the height of the tidal lift will be the same, and therefore a greater distance can be covered on the succeeding tide after the sunken craft has been lifted over the bank. This is well illustrated by Fig. 14, if the second movement is contrasted with the third. The lifting craft was steered starboard bow to the tide, and the speed over the ground was kept down generally to 1 knot, but if the submarine touched bottom controllability was lost, and the lifting craft fell broadside to the tide. The two ahead tugs had then to steam up into the tide broad off the starboard bow. On the occasion to which particular reference has been made the tugs were unable to keep position and fouled each other, causing some anxiety in case they should be compelled to cast off.

Fig. 6, on page 50, shows the arrangement of the wires around the bollards after pinning. After the ninth move inshore the operations passed into the final stage, which involved bringing the submarine to the surface by means of compressed air, but war had been declared; H.M.S. Tedworth was withdrawn, although two of her divers remained to assist the Association's own divers.

The plan was for divers to strongback the various hatches, except the engine-room hatch, for which was substituted a plate into which were fitted one 6-in. syphon pipe that would reach down to the engine-room platform, and one 2-in. flexible syphon pipe that could be lowered into a sump adjacent to the forward engine-room bulkhead. A group of three air-injection valves was also fitted into this plate, as well as three other air-injection valves, so that, as the water was lowered throughout the submarine abaft of No. 40 bulkhead, and a larger volume of air was required to maintain a full discharge through the syphon pipes, this additional volume could be provided by bringing into action as required any or all three valves to supplement the three grouped valves. Buoyancy had to be restored to the compartments forward of No. 40 bulkhead by compressed air, injected through a valve to be fitted in the torpedo hatch, which would blow out the water through the open No. 5 torpedo tube. Nos. 2, 3, 4, 5 and 6 external tanks on the port and starboard sides of the submarine were to be controlled by compressed air injected through valves to be fitted into the tops of the respective tanks, and the No. 1 main ballast tank, which passed under the bow, was to be drained by compressed air injected through an air pipe clamped into one of the flooding holes. Each of the air-injection valves was controlled by a cock operated by divers, non-return valves being useless as they would not permit the compressed air to be released whenever this might be required.

Fig. 15.

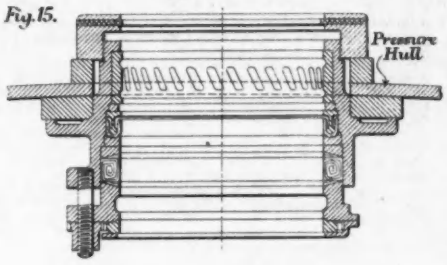
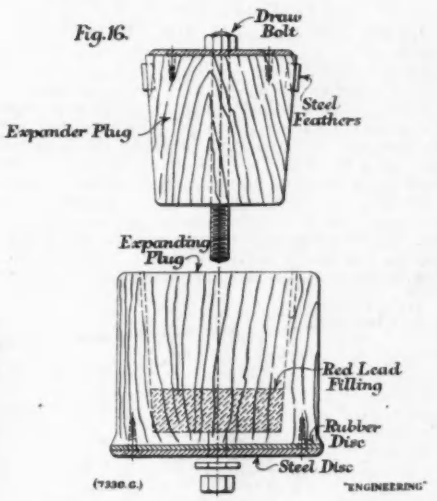


Fig. 16.



This plan, although apparently straightforward, was so much hampered by the conditions that it could not be completed until October 23, when the vessel was refloated and taken stern first inshore to a position where the stern was practically high and dry at low water. The beach was sheltered from prevailing south-west and west winds, and partly sheltered from north-west, but, as if by malign perversity, the prevailing winds did not prevail; from September 10, when the weather broke, there were persistent strong northerly and north-easterly winds, accompanied by heavy swell and frequently rough seas, and, in fact, during the period of 68 days while the vessel lay on the beach there were only 21 days when work was possible, and on some of these days only for a few hours.

The report of the Public Tribunal has disclosed that 67 victims of the disaster had congregated in the engine room and 32 in the after crew space. It was necessary to remove the bodies from the engine room to enable divers to obtain access to the control room and mess room, in order to open bulkhead doors to permit free flow of compressed air and drainage of water abaft No. 40 bulkhead, as well as to perform other necessary preparatory work. It will be a consolation to any relative of the victims who may read this paper to know that no consideration of expediting the work of salving the vessel was allowed to interfere with the removal of the bodies with the greatest possible decorum and care for their preservation. This consideration was so strongly sustained that the work of evacuation, which commenced on September 7, was not completed until September 30.

When divers were eventually able to obtain access to the control room it was found that air exhausting from the diving dresses was reaching the sea surface in way of the conning tower. It was presumed that there was leakage through the conning tower hatch, but investigation showed that the leakage was through the forward periscope, which had been broken off during the last stages of the lifting operations. This indicated leakage past the gland, and it became necessary to withdraw the cross head. After this had been done, and the bearing ring had been removed, a plug was inserted by divers into the forward periscope tube.

By October 11, everything was in readiness for a compressed-air test of the main body of the vessel, and at 10.33 a.m. blowing was commenced, but after 30 minutes a serious leakage developed in the vicinity of the conning tower. It was found that the leakage was coming through drain holes on the fore and after sides of the faucet in the forward periscope casting, but there were no signs of leakage elsewhere. Connections were made to additional air-injection valves in the plate over the engine-room hatch. Blowing was resumed the next day with increased volume and the 6-in. syphon pipe commenced to discharge water. After continuous blowing for six hours further air leakage occurred, which was found to be coming from the port main-engine exhaust pipe. This was plugged and blowing was resumed at 11 a.m. on October 13, but at about 4.40 p.m. air commenced to escape from the starboard main-engine exhaust pipe, and the syphon pipe stopped discharging water. The cause of the air finding its way through the engines was not understood at that time, but investigation of the construction of the engines, which were of two-stroke design, revealed that one of the pistons in each engine could be in a position where the inlet port and the exhaust port could be open simultaneously, thus explaining the passage of the compressed air. In these circumstances it became necessary to open up the engine-room hatch to enable divers to test the group exhaust valves. It was found that the port-engine group exhaust valve was half a turn open and the starboard engine valve two turns open, and these were closed. An investigation of the cause of the leakage through the forward periscope tube showed that the plug had seated on the bottom of the gland and that both plug and gland were loose. It was deduced that the withdrawal of the periscope had disturbed the packing in the stuffing box above the gland and that air was escaping between the gland and the periscope tube.

Fig. 15, on this page, is a diagram of the bottom section of the periscope tube, from which it will be seen why the tapered end of an ordinary plug allowed the escape of air between the gland and the periscope tube, given that the packing in the stuffing box had been disturbed. An expanding plug was constructed, to reach up to the U leathers in the periscope tube and be sealed by expansion at its inner end against the neck ring of the stuffing box. Fig. 16 is a diagram of the expanding plug.

The fitting of this plug did not bring all the difficulties to an end. When divers descended on the afternoon of October 20, to make connections to the air-injection valves fitted to the after external tanks, it was found that these were buried in mud, that the stern of the submarine had settled in the mud during the periods of bad weather, and that the tail was just clear, from which it followed that the after hydroplanes were buried in approximately 6 ft. of mud. On the following morning a diver was sent down with a deck hose to try to clear the buried air cocks, but after an hour's work he failed to locate them. Blowing of the compartments forward of the No. 40 bulkhead and of the main body of the submarine, as well as of the Nos. 2, 3 and 4 port and starboard external tanks, was commenced, and was continued until the late afternoon, when the 2-in. syphon pipe commenced to exhaust air. A diver was then sent down and reported the No. 5 and No. 6 port and starboard air-injection valves clear above the mud. The submarine was maintained in a condition of just negative buoyancy during the ebb tide in the hope that the mud would be scoured from the stern. Blowing was resumed on October 22. Shortly after midday the bow surfaced and sank slowly, but after 30 minutes, during which blowing was continued, the bow again surfaced and remained. Air pressure was then released from the forward external tanks to permit the bow to settle again, as it was feared that with the strong flood tide it might be uncontrollable. Divers were again sent down and found the after hydroplanes and propellers clear of the mud, but a big volume of mud was held between the propeller shafts. As it was apparent that, with the trim of the submarine by the stern, a sub-

stantial body of water remained in the after crew space, a hole was drilled through the pressure hull below that space and an air compressor was kept running all night on the injection valves in the plate fitted over the engine-room hatch.

In the early morning of October 23, a diver reported that there was a good discharge through this hole, but a leakage of air was discovered from a pipe, 6 in. in diameter, adjacent to the No. 6 port external vent. This was presumed to be an overside discharge from a 100-ton pump, and was plugged. At 2 p.m. the stern came to the surface, blowing was commenced on the compartments forward of No. 40 bulkhead, and on the forward external tanks, and at 2.30 p.m. the bow surfaced with a 2 deg. list to port. The submarine was then drawing 17 ft. forward and 15 ft. 3 in. aft, and was taken well up the beach stern first. Later the bow was hove inshore to a position where the open bow cap of the No. 5 torpedo tube was exposed at low water, the vessel was deodorised and made reasonably fit for entry by persons authorised to take evidence, and thereafter she was towed to Holyhead and dry-docked. No damage of any significance had been caused by the salvage operations, and on November 18 we safely delivered her to her birthplace at Birkenhead.

CATALOGUES.

Welding Electrodes.—Messrs. Hadfields, Limited, East Hecla and Hecla Works, Sheffield, have sent us a pamphlet dealing with their "Hadmang" electrodes and welding rods.

Precision Parts.—Messrs. Rotherham and Sons, Limited, Coventry, have sent us a folder referring to their facilities for the supply of precision-made instruments and parts.

Black-Out Ventilators.—Messrs. Colt Ventilation, Limited, Bush House, Strand, London, W.C.2, have produced a light-tight ventilator which is described in leaflets recently received from the firm.

Precast Concrete Floors.—We have received a pamphlet from Messrs. Concrete, Limited, Green-lane, Hounslow, Middlesex, describing precast Bison floors, designed according to L.C.C. regulations.

Steel Balls for Grinding.—Messrs. Hadfields, Limited, East Hecla and Hecla Works, Sheffield, have issued a descriptive pamphlet dealing with "Hecla" hard forged-steel balls for ball and tube mills.

Aluminium Alloys.—Messrs. The British Aluminium Company, Limited, whose temporary address is Raven Hotel, Castle-street, Shrewsbury, Shropshire, have sent us some recently-published data on aluminium sheet and sections.

Boiler-Draught Fans.—We have received from Messrs. Sturtevant Engineering Company, Limited, 147, Queen Victoria-street, London, E.C.4, a pamphlet (No. 1077 A) dealing with large fans for forced, induced and balanced-draught installations in boiler plants.

Bakelite Products.—We have received from Messrs. Bakelite, Limited, Brackley Lodge, Brackley, Northamptonshire, a revised booklet dealing with the properties, uses and grades of their various products, together with directions for machining processes.

Air Compressors.—Messrs. Worthington-Simpson, Limited, Newark-on-Trent, have sent us a brochure describing their vertical double-acting water-cooled compressors, suitable for coupling directly to electric motors and internal-combustion engines. These can also be arranged for Vee- or for flat-belt drive, and range in piston displacement from 100 cub. ft. to 900 cub. ft. per minute.

Castings.—We have received from Messrs. Davy and United Engineering Company, Limited, Park Iron Works, Sheffield, 4, a publication illustrating typical castings manufactured by their subsidiary company, Messrs. Davy and United Roll Foundry, Limited, Billingham. Castings up to twelve tons finished weight are undertaken by this foundry, which has been recently modernised.

Welding Electrodes.—A leaflet received from Messrs. Lincoln Electric Company Limited, Welwyn Garden City, Hertfordshire, describes an interesting experiment conducted to prove that an unskilled labourer can be instructed, in one hour, to produce welds satisfying the all-weld metal requirements of the Board of Trade and the classification societies for work of primary structural importance.

Laboratory Apparatus.—Messrs. Griffin and Tatlock, Limited, Kemble-street, London, W.C.2, have sent us leaflets giving particulars of their recent productions in laboratory apparatus. These include a large-capacity gas generator intended to replace Kipp's apparatus; a lever-type balance for loads up to 200 grammes, reading to 0·5-gramme; gas-analysis apparatus developed by the Gas Light and Coke Company; and Pyrex sintered glassware for laboratory use.

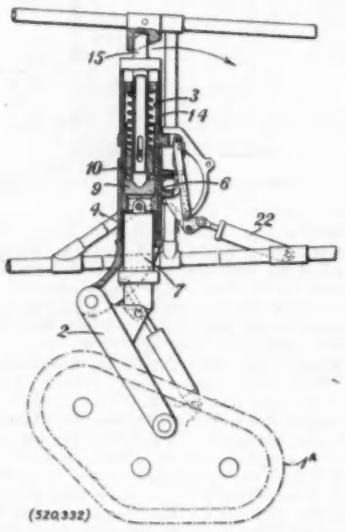
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

520,332. Aircraft Landing-Gear. G. H. Dowty, of Cheltenham. (1 *Fig.*) September 17, 1938.—A rigid frame supports an endless track 1^A and is pivoted to a lever 2. This lever is pivoted to an extension on a sleeve 3 which rotates in a tubular fitting 4, pivoted on a retraction pivot 6. The sleeve 3 has a transverse diaphragm supporting the cylinder 7 of a telescopic shock absorber, the piston being pinned to a lug on the lever 2. On landing, the lever 2 swings up and back against the shock absorber which is allowed just sufficient play to take account of the horizontal component of movement of the lug. To control the orientation of the track unit, a centring cam 9 is fixed in the sleeve on top of the diaphragm and engages a second and non-rotatable centring cam 10,



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which slides in the sleeve against a compression spring. An outer locking sleeve 14 carries a lock pin 15 engaging a ramped catch fixed to a top longeron frame of the aircraft. A lug on the lower end of the locking sleeve carries a pivot pin for a link, the other end of which is pivoted to a small bellcrank the fulcrum of which is on an arm fixed to the fitting 4. To the bellcrank is also pivoted the piston of a double-acting retraction jack 22, anchored to a bottom longeron frame. Between the top and bottom longerons, frame members carry the retraction pivot 6. To retract, the jack 22 first swings the bellcrank to pull down the sleeve 14, releasing the lock 15. Further extension of jack swings the whole mounting and track unit about the pivot 6 into the retracted position. (*Accepted April 22, 1940.*)

HYDRAULIC APPARATUS.

519,968. Föttinger Coupling. A. V. Oliver, of Leamington Spa. (7 *Figs.*) October 26, 1938.—The coupling is of the type in which the control of the transmission of power is effected by movable vanes arranged to control the internal circulation of the oil. The engine flywheel carries the driving element 3 of the coupling, the vanes 3a of which are cut away at their free edges to accommodate pivoted vanes 5 for the outer and inner orifices of the coupling. The pivot pins extend through the core 7 of the coupling and are coupled together by pinions 8, which are in constant mesh. The vanes are rotated from an outside control by racks 9, which are in constant mesh with some of the pinions 8. The outer ends of these racks project through stuffing boxes and are operated by a plate 11 sliding on a sleeve on the driven shaft under the control of a pedal. In the open position, the pivoted vanes form continuations of the fixed vanes. In the closed position, Fig. 2, they form an effective screen between the driving and driven elements and completely cut off the flow of oil from one element to the other. Between these two extreme positions the pivoted vanes can be set to vary the velocity of the circulating oil. Owing to the narrowing of the orifices between the fixed vanes as they approach the centre of

Fig. 1.

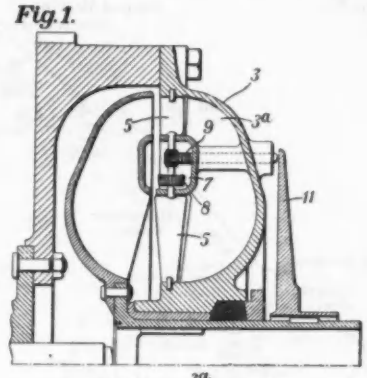
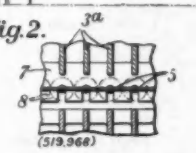


Fig. 2.



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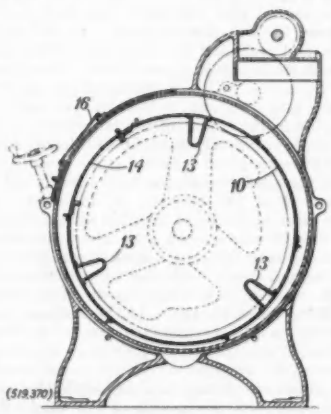
the coupling, it is usual to omit alternate vanes at the inner orifices, and the number of pivoted vanes for these orifices is proportionately reduced, the vanes being made of double width. (*Accepted April 10, 1940.*)

MISCELLANEOUS.

519,370. Washing Machine. Chorley and District Hygienic Laundry, Limited, of Chorley, and J. L. Hill, of Chorley. (7 *Figs.*) August 19, 1938.—The invention is a rotating-drum washing machine of the kind which operates with a reversing action, the drum being rotated rapidly, say, three revolutions in one direction, and then three revolutions in the reverse direction, and the object of the invention is to provide for the re-entry of the washing water during rotation of the drum after it has been expelled by centrifugal force. The drum 10 of the machine is about 3 ft. in external diameter and there is about $\frac{3}{4}$ in. clearance at the bottom and $2\frac{3}{4}$ in. at the top between it and the casing. Six longitudinal ribs of angle iron on the drum just clear the bottom of the casing, allowing for expansion by heat, etc. Inside the drum are the usual "tumblers" 13, and it has a hinged



(519,370)

cover 14, while the casing is provided with an aperture fitted with a sliding cover in which is an inspection window 16. A pedal-operated valve in the bottom of the casing is held shut by a counterweight. The ends of the casing each have an inwardly projecting ring concentric with, and of slightly larger diameter than, the adjacent end of the drum, so that the cylinder can expand in diameter as well as in length and also float slightly endwise on its shaft without actually rubbing the ring. In operation, the washing water is forced out of the drum by centrifugal force, particularly at the bottom. Up the sides, centrifugal force still resists re-entry of the water, so that it collects up the face of the drum as it is lifted by the longitudinal ribs, which act as a pump. Towards the top, however, these forces in the drum diminish while the pumping action outside the drum decreases due to the widening of the space between the drum and the casing. The static head resulting from the combined centrifugal action within the drum and the pumping action between the drum and the bottom of the casing is therefore greater than the resistance to re-entry, and consequently the water is able to re-enter the drum at its upper part. (*Accepted March 26, 1940.*)